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RELATIONSHIP OF EFFLUENT LIMITATIONS TO FUTURE PULP MILL CLOSURES

Robert L. Coughlin

Environmental Protection Agency
Seattle, Washington

December 1972

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RELATIONSHIP OF EFFLUENT LIMITATIONS TO FUTURE PULP MILL CLOSURES

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Robert L. Coughlin
Economist

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U.S. Environmental Protection Agency
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INTRODUCTION

Section 302 (b) of the Federal Water Pollution Control Act of 1972 stipulates that under some circumstances the economic and social costs of achieving effluent limitations shall be taken into account in determining the nature of such limitations.

That is a particularly difficult directive for the economist to grasp. He operates from an intellectual base that dictates that every human action, every human choice has a cost (and that there are ultimately only social and economic costs). His creed is contained in the maxim that "there are no free lunches."

It is probably the case that the law requires that what is to be evaluated is the magnitude of the implicit income transfer involved in setting a particular effluent limitation. In effect, the question becomes: how many jobs, how much production, and how much environmental amenity must competitive producers and consumers be asked to forego in the event that a substandard effluent limit is required to maintain the status quo at a particular site? Phrased in that fashion, the question becomes intelligible. Obviously, however, it is no longer a technical economic question. It is the essence of the political dilemma, the basic problem in social morality that government exists to resolve.

The legitimate task of the economist, then, can be little more than to establish the economic context for each such political decision. He is to set in place the series of functions whose relative dimensions and interplay bear upon the social and political decision process--price effects, temporal dimensions, raw materials and labor supply, capitalization, demand trends. Understanding these, the decision maker may better understand the probable consequences of his decisions, the amount of continued employment and its extent in time that can be transferred from the global and national communities to relieve or postpone distress for a particular firm, establishment, or community.

This study is an effort to draw that economic context fc the industry that is generally conceded to be most significan to water pollution in Federal Administrative Region X. It is pointed to the solution of a single problem, determining the impact of waste treatment on production costs of the Region's pulp mills, and relating it to fundamental industry dynamics in order to forecast the likelihood of plant closures.

Hopefully, this technical exercise will assist the broader minds and larger responsibilities of those who may be forced to determine the relative economic and social costs of setting particular effluent limitations.

CONCLUSIONS

1. Growth of the Pacific Northwest woodpulp industry will be constrained in the future by the relatively complete utilization of raw materials that already exists. The industry is undergoing a process of concentration that features vertical integration of forest products output; fewer firms; fewer, larger, and more specialized pulp mills. Labor requirements are dropping steadily, and employment can be expected to fall significantly--4000 to 7000 jobs-- over the next decade.

2. Pulp production, and related paper manufacturing, is the largest single source of waterborne waste discharge in Region X. Daily waste discharge of the industry amounts to almost a billion gallons of water, more than 3.5 million pounds of five day biochemical oxygen demand, and 1.3 million pounds of settleable, floating, and suspended solids. There is enormous intermill variation in discharge per unit of product, due to differences in production processes employed, degree of bleaching, and amount of waste treatment provided prior to discharge.

3. Costs of treating wastes to reduce their polluting strength vary with volume of water to be treated, the concentration, specific gravity, and rate of decay of potentially polluting materials to be reduced or counteracted, and the degree of waste reduction that is required. There are economies of scale and of complementarity in waste treatment that provide definite cost advantages to larger dischargers. The treatment strategy is basically modular, so that treatment cost increases tend to occur as a series of interrupted plateau functions rather than a continuous progression.

4. Region X mills had invested about $96 million (1967 purchasing power) in waste treatment by August, 1972 and were incurring more than $18 million a year of waste treatment costs. To achieve what has been the generalized waste treatment goal, i.e., "the equivalent of secondary waste treatment," will require the investment of another $82 million and impose an incremental annual cost of $13 million. Mean current cost of waste treatment per ton of output is $2.80, and another $2.00 a ton will be added if the equivalent of secondary waste treatment is to be achieved. These costs are divided very unevenly among operating mills according to their size, product mix, and degree of waste treatment currently provided.

5. Substitution of the specific effluent limits that constitute the current interpretation of "best practicable control technology" for the more general technological requirements utilized under prior law may add more than $90 million to Region X pulp mills investment requirements over the next five years and about $12 million, $1.70 per ton of output, to annual costs. Total investment, then, may amount to about $260 million, total annual costs to $41 million, or $6.50 per ton of pulp output.

6. Although pulp mill closures that may be anticipated over the next five years are to be construed largely as accommodation to fundamental economic forces--industry concentration, relocation to patterns of raw material availability, adjustment to economies of scale and to technological influences--water pollution control will play a part in such closures by (1) reinforcing competitive advantages, and (2) modifying the timing and purpose of investment programs. Two Region X pulp mills are thought to be almost certain to close by July 1, 1977, two more have a definite probability of closure, and closure is possible though less likely in two other cases. Gross capacity involved is slight, a minimum of 206 tons per day, a maximum of 971 tons per day, of a total current capacity of 19,968 tons per day.

I. INDUSTRY BACKGROUND

The imperatives of water pollution control law would appear to demand that Region X pulp mills provide about $260 million worth of capital facilities for the treatment of wastewater by 1977, and that they add at least $41 million a year to the selling prices of their products in order to meet the costs of wastewater treatment. (Actual price increases will probably come closer to $52 million, assuming maintenance of the industry's characteristic markups. It should be noted, too, that all values are presented in terms of 1967 purchasing power, so convey no more than 70 to 75 percent of their August 1972 impact.)

These are very significant sums. As a rough calculation, it would require more than $3 billion to reproduce the region's pulp producing physical capital (with complete air and water pollution control facilities), and the region sells about a billion dollars worth of pulp each year. Water pollution control then, could account for as much as 9 percent of the capitalization, and 5 percent of the product value of Pacific Northwest and Alaskan wood pulping by the end of the current decade.

Quite obviously, expenditures of the indicated magnitude will have influences on the behavior of firms, and these will extend to availability of employment opportunities and the commercial prospects of the communities in which pulp mills are presently located.

It should be equally obvious, however, that those impacts cannot be isolated from other influences that bear upon the industry. The position that is often advanced (mercifully, it is heard with increasingly less frequency as time passes) that pollution abatement costs are so great that they will cause plants to close can be considered blatant nonsense. But so can the claim of the emotional environmentalist that pollution control costs should have no influence on operational circumstances, or that they can be entirely met out of profits.

Conventional economic theory dictates that pollution control is a cost that, like any other value added to a product, will be passed on to the consumers of that product to the extent possible, even to the extent of marking it up and deriving a profit from it if at all possible. And like any other incremental

cost, it carries with it the possibility of closing some plants, depending on their innate profitability and their ability to control that cost relative to the abilities of competing plants. If one is to gage the response of Region X pulp mills to environmental regulation, he must consider regulatory cost in the context of industry trends, raw materials availability, market prospects, and inter-plant variations in efficiency. It seems unlikely that water pollution abatement has, by itself, closed or will ever close a pulp mill in Region X; it is even more unlikely, however, that water pollution abatement, because it imposes a capital demand and imposes shifts in costs structures, has not been a consideration in capitalization decisions, or that it will not affect such decisions over the next few years.

Raw Materials

The ultimate constraint on volume and location of woodpulp production is the availability of the basic raw material, wood. Although Pacific Northwest forests are abundant and prolific, their production capacity is already very fully utilized. In western Washington and northwest Oregon, cutting has for some years been geared to sustained yield considerations. In southwestern Oregon, where old growth forests still predominate, the current cut is well in excess of the sustained yield. In response to the growing squeeze on raw materials, the U. S. Forest Service has relaxed allowable cut formulae several times in the last decade, as have other land management agencies. Forest products industries have made serious adaptations to accommodate increasing scarcity, notably by broadening utilization of raw materials through by-product development (hardboard, "lignosite" talloil, bark mulch), utilization of residues, and by industry concentration.

The location of pulp producing capacity reflects, in a very general way, the location of raw materials supplies. (cf. Table 1).

Table 1
Pacific Northwest Timber Cut, 1963

	Millions of Board Feet					24 hour Pulping Capacity			
	Nat'l Forest	Other Public	Private Forest	Total	%	1963	1972	% 1963	% 1972
Western Oregon	2,340	1,470	4,170	7,980	42	3,225	7,431	23	38
Western Washington	1,280	640	3,980	5,900	31	9,120	9,447	64	48
Eastern Oregon	1,079	90	685	1,854	10	--	--	0	0
Eastern Washington	414	343	370	1,127	6	510	732	4	4
Idaho & W. Montana	1,194	--	1,035	2,229	12	1,350	2,000	10	10
TOTAL (tons & %)	6,307	2,543	10,240	19,090	100	14,205	19,610	100	100

That the correlation of pulping and logging activity is not closer is not surprising. Pulp mills are initially located where there is opportunity for intensive logging, but trees once cut down take a long time to grow back, and pulp mills are not portable. In the nature of things, then, timber cut moves progressively further from the physical capital upon which it is based. Because each mill embodies a large amount of capital, it is not apt to be closed as its timber supply grows more remote. The long run adjustment of pulp production to wood production has been dependent on growth of the industry--the new mill invariably locates at the nexus of then current logging activity--and the overall composition of the industry at any point in time necessarily reflects the past rather than the then current locational optimum.

If one considers the Pacific Northwest in terms of wood supply areas, three broad regional groupings compose themselves quite naturally. The largest (in size, not in forest supply) is the area between the Cascades and the Rockies--eastern Oregon and Washington, plus the state of Idaho, and western Montana. West of the Cascades, the Columbia River divides the Douglas Fir region into an Oregon and a Washington segment--the one extending into northern California, the other into southern British Columbia so far as forest utilization arrangements are concerned.

Within these rough borders, there is a distinct difference in the ratio of timber cut to pulp production, a difference that is largely a reflection of the locational lag. If one reviews the ratio of timber cut to pulp output of each area in 1963, he finds that western Washington produced twice as much pulp as Western Oregon, and 3.5 times as much as the area east of the Cascades, for each unit of timber cut within the respective areas.

The 1963 pulp production per unit of logging output was:

Pacific Northwest--1 ton of pulp per 4000 board feet cut.
East of Cascades--1 ton of pulp per 8400 board feet cut.
Western Oregon--1 ton of pulp per 4800 board feet cut.
Western Washington--1 ton of pulp per 2400 board feet cut.
West of Cascades--1 ton of pulp per 3400 board feet cut.

(The ratios for western Oregon and western Washington assume that lower Columbia River mills were supplied equally from either state.)

Obviously enough, such general relationships include a broad variety of detail, notably the relative forest products specialization in each area and inter-supply area exchanges of wood. Western Washington's pulp and paper industry, and western Oregon's to a lesser extent, subsist to a considerable degree on inshipment of roundwood and pulp residue from areas east of the Cascades, and from British Columbia as well in the case of western Washington. There are, in addition to prevailing westward movements of raw materials, significant north and south exchanges between western Oregon and western Washington. Price, ownership of forest lands and of wood products establishments, contractual arrangements, and custom establish links between the forest sources of wood and the ultimate pulp producing activities in a balance of arrangements that is shifting and irregular, but tends to be based in large measures on intra-firm considerations.

Two very basic production/raw material trends can be discerned. In the short run, movement of wood is from the forests, wherever located, to the pulp mills, wherever they may be located. But over the longer run, the location of pulping capacity has been shifting to accommodate the configuration of wood supplies. (In the past, growth has been the force that shaped the correspondence of new mills to available wood sources. Increasingly, however, replacement of obsolescent mills causes the accommodation to take the form of locational change rather than unequal expansion.) Increasing strain on available wood supplies has led to progressively more intense use of wood. Twenty years ago, lumber, plywood, and pulping competed actively for the same log. In the Pacific Northwest today, more than 60% of wood imputs to pulp mills are the residues of lumber mills and plywood mills. Logs tend to be separated according to species and quality for best use and maximum yield. The probable Pacific Northwest timber cut in 1972 will be about 20.5 Billion board feet--7.5% above the 19.1 billion board feet of 1963. But the 6.5 million tons of pulp that will be produced in the area (includes western Montana) is about 38% greater than 1963's output. That increase did not come primarily from diverting logs from lumber and plywood production, but from fuller use of the available wood supply.

Since wood is in short supply--at least relative to its past abundance--and since there is a propensity to locate pulp mills at the point of supply, the future locational situation of the industry can best be gaged by assessing prospects for wood supply. The U. S. Forest Service has provided such an assessment. (Prospective Economic Developments Based on the Timber Resources of the Pacific Northwest: USDA, Portland, Oregon, 1966.) That evaluation is not an optimistic one. It suggests that by 1985 the Pacific Northwest can sustain a timber harvest of about 21.3 billion board feet--very little above the current cutting rate. (cf. Table 2).

Table 2
Prospective 1985 Timber Cut

	Millions of Board Feet				
	Nat'l Forest	Other Public	Private Forest	TOTAL	Shift From 1963
Western Oregon	2,550	1,860	3,840	8,250	+3%
Western Washington	1,400	640	4,710	6,750	+14%
Eastern Oregon	1,150	102	708	1,960	+6%
Eastern Washington	441	366	376	1,183	+5%
Idaho & W. Montana	2,044	--	1,194	3,238	+45%
TOTAL	7,585	2,968	10,828	21,381	+12%

Some basic trends and assumptions underlie the projection. Forest management will be significantly more intense as time passes. The age composition of southwestern Oregon forests will continue to impose a cut above the sustained yield rate throughout the period. Western Washington and northwest Oregon forests will achieve increasing productivity through the period as a function of regrowth of cut over lands, but will be very near the ultimate sustained yield optimum by 1985. Productivity of private and state owned forest tracts will approach that of national forests--a questionable assumption, in view of urban and recreational encroachment and the permanent passage of many farm wood lots into pasture. And, wood supplies will continue to be diverted from lumber for production of plywood, hardboard, and woodpulp--also debatable, as discussed below, in terms of price and demand relationships evolving in forest products industries.

Quite clearly, limitations on available wood supplies are becoming a progressively more significant determinant of pulp and paper output in the Pacific Northwest. Projected cutting rates for 1985 could not have supported 1972 output of the industry at the 1963 rate of conversion of timber cut to pulp output. Even the very high 1972 pulping to cut ratio provides little room for expansion over the succeeding thirteen years. If the whole region were, by 1985, to sustain western Washington's rate of pulp output to timber cut for 1963, growth in that thirteen year period would no more than equal that of the last decade. (The probability of such growth must be considered slight, in that western Washington could only sustain its pulp output in 1963 by deemphasizing lumber and plywood production and by imports of raw materials from Canada and from logging east of the Cascades.)

Table 3
Indicated Pulp-sustaining
Capacity of PNW Forests in 1985

	Western Oregon	Western Washington	East of Cascades
1. pulp-producing capacity @ regional 1963 conversion rate	6,200 T/D	5,100 T/D	4,800 T/D
2. pulp-producing capacity @ regional 1972 conversion rate	8,000 T/D	6,500 T/D	6,200 T/D
3. pulp-producing capacity @ western Washington 1963 conversion rate	10,300 T/D	8,500 T/D	8,000 T/D
Industry Capacity, 1972	8,450 T/D	8,500 T/D	2,700 T/D

In summary, it would appear that future growth of the industry must be limited for the region as a whole, and that the western Washington element of the industry can only be sustained at the expense of other parts of the region or at the expense of timber and plywood production.

Organizational Trends

As raw materials supplies have become characterized by scarcity relative to demand, the operation characteristics of Region X's pulping industry have also changed. The number of plants has shrunk, their average size has increased, and ownership has shifted into fewer hands. (cf. Table 4)

A decade ago, major forest products firms had already come to dominate the industry. The degree of their control has increased--though their composition has broadened. Crown Zellerbach and Weyerhaeuser Co. accounted for 43% of the region's pulping capacity in 1963 (includes the latter firm's relationship with Potlach Forests based on common dominant stockholders). By 1972, the two Pacific Northwest giants accounted for only 35% of capacity. Boise Cascade and Georgia Pacific had become their

Table 4
Concentration Trends

1. Establishments Operated by Firms with Sales in Excess of $1 Billion

FIRM	Indicated 1972 Sales ($ Billions)	Establishment	Capacity	Establishment	Capacity
American Can	2.0	--	--	1	330 T/D
Boise Cascade	1.7	1	375 T/D	4	1936 T/D
Crown Zellerbach	1.1	7	3150 T/D	6	3098 T/D
Georgia Pacific	1.8	1	600 T/D	2	1569 T/D
International Paper	2.1	--	--	1	600 T/D
International Telephone & Telegraph	N.A.	--	--	2	990 T/D
Weyerhaeuser Company	1.6	5	2460 T/D	4	2211 T/D
TOTAL		14	6585 T/D	20	11,334 T/D
Percent of Total		39%	45%	63%	58%

2. Establishments Operated by Firms Controlled by Other Firms with Sales in Excess of $1 Billion

Ketchikan Pulp	N.A.	1	450 T/D	1	630 T/D
Potlatch Forests	1.4	1	650 T/D	1	1000 T/D
TOTAL		2	1100 T/D	2	1630 T/D
Percent of Total		6%	8%	6%	8%

3. Other Firms

Alaska Pulp & Timber	N.A.	1	600 T/D	1	725 T/D
Fibreboard Paper Pdts	0.2	1	105 T/D	--	--
Inland Empire Paper Company	N.A.	1	135 T/D	1	66 T/D
Columbia River Paper Company	--	2	300 T/D	--	--
Longview Fibre Company	N.A.	1	1455 T/D	1	1850 T/D
Menasha Company	N.A.	1	125 T/D	1	150 T/D
Publishers Paper Company	N.A.	1	420 T/D	2	1094 T/D
Puget Sound Pulp & Timber	--	1	570 T/D	--	--
Rayonier	--	2	775 T/D	--	--
St. Regis Paper	0.9	1	750 T/D	1	887 T/D
Simpson Lee	N.A.	1	80 T/D	--	--
Washington Pulp & Timber	--	1	65 T/D	--	--
Western Kraft	N.A.	1	250 T/D	1	770 T/D
West Tacoma Newsprint	--	1	165 T/D	--	--
Scott Paper Company	0.8	3	990 T/D	2	976 T/D
Spaulding	--	1	150 T/D	--	--
TOTAL		20	6835 T/D	10	6518 T/D
Percent of Total		56%	47%	31%	33%
ALL ESTABLISHMENTS		36	14,520	32	19,482

peers, largely through acquisition of existing mills. Other major forest products firms, American Can and International Paper, had staked out a claim in the Northwest by constructing new mills. And a major conglomerate, ITT, had moved into the region and into the industry by acquisition of Rayonier, Inc.

But while some were becoming giants and other giants were moving in, lesser forest products firms were disappearing from the area. Fibreboard Paper Products and Simpson-Lee concentrated their pulp and paper operations in other parts of the west. Columbia River Paper, Puget Sound Pulp and Timber, Rayonier, and Spaulding disappeared in the acquisition process. The region will go into 1973 with almost 70% of its pulping capacity owned or controlled by seven major firms. Nor are the eight smaller firms that remain minor competitors. St. Regis and Scott Paper companies are powerful national forces whose annual sales hover around a billion dollars. Longview Fibre operates the largest pulp mill in the Northwest, one of the largest in the nation. Publishers Paper is owned by the Los Angeles Times Co., and Alaska Lumber and Pulp by a consortium of Japanese chemical and paper firms. In less than a decade, the industry has shifted from one composed of 22 firms operating 36 establishments of a mean productive capacity of 403 T/D to one of 17 firms operating 32 establishments of 541 T/D average capacity. Growth, concentration, and enormous cash flow have been its characteristics.

The same characteristics may be observed within the operations of individual firms. Both Weyerhaeuser and Crown Zellerbach have divested or are in the process of divesting themselves of one establishment, the former by closure of a mill, the latter by a sale. Some pulping operations have been discontinued at two Crown Zellerbach Mills (at West Linn and Port Angeles), at Inland Empire Paper Co., and at one Boise Cascade mill (at Vancouver, Washington). Fewer mills, of larger size and greater specialization, would appear to be the order of the day.

Dependence on residuals as the prime raw materials source has reinforced the tendency to concentration. Ownership of lumber and plywood mills contributes to the movement of raw materials from the forest through the various production processes in a manner that allows for optimum utilization of each log and adjustment of production flows to the varying demand configurations of the several markets for wood products. Much of the growth of the Oregon pulping industry can be traced to that sort of integrated production, in that the chipped residues of the State's vigorous Douglas Fir lumber and plywood

industry have provided an attractive raw material supply for sulfate pulping. Conversely, Alaskan spruce and Washington hemlock, less desirable lumber species, have produced a specialization pattern that combines sulfite pulping, a monopoly of the regional output of dissolving pulps, and a considerably greater reliance on roundwood inputs. Integration in their case tends to be from forest to pulp mill, without the intermediate stage of lumber and plywood production that is common in Oregon, southwest Washington, and east of the Cascades.

Integration and specialization have extended to marketing as well as production patterns. When Fibreboard Paper Products and Simpson-Lee decided to close obsolete mills, production was shifted to locations closer to major markets rather than replaced in the Pacific Northwest. The imminent closure of the Weyerhaeuser dissolving pulp mill at Everett can be traced to the opening of a mill at New Bern, North Carolina--again, a location closer to markets. Production of market pulp has almost ceased, with the obvious exception of dissolving pulps. Though several mills have experienced an increase in degree of specialization, output tends to be converted into paper products at owned mills in the Pacific Northwest. (Two exceptions to the pattern of production integration persist. The Scott Paper Co. mills and the Georgia Pacific sulfite mill at Bellingham continue to produce pulp well in excess of regional marketing requirements. The surplus, however, is utilized almost entirely in owned paper mills in eastern States.)

Competition for Raw Materials

It has been indicated that concentration in the pulping industry extends into other phases of forest products output. That relationship can be considered critical in appraising the future prospects of the industry. Sales of wood products and of wood fibre products are in approximate balance for Boise Cascade, Crown Zellerbach, Georgia Pacific, Weyerhaeuser, and Potlatch Forests. Wood products account for a lesser, but significant, portion of the sales of International Paper and St. Regis Paper. American Can, Longview Fibre, and Western Kraft all operate in circumstances in which the availability and price of their raw materials supply, which is substantially derived from chipped residuals, is strongly affected by markets for lumber and plywood.

Traditionally, lumber has been a relatively low priced commodity with a cyclical demand pattern. It has been the variable that determined the price structure for wood as an industrial raw material. The values added and the profits derived from

pulping, plywood production, and papermaking have rested in large measure on the initial low raw material price established by lumber demand. And the presence of literally thousands of small entrepreneurs--"gyppo" loggers and sawmill operators--provided flexibility and price competition in forest exploitation that virtually insured a favorable raw materials cost for the pulp and paper industry.

With increasing scarcity of sawtimber and with replacement of entrepreneurial lumbering by concentrated ownership--the U.S. Forest Service has estimated that the number of firms active in Pacific Northwest lumbering has declined to 25% of the 1950 level --the umbrella over raw materials prices has sprung holes. Entry of Japanese firms as active, eminently competitive log buyers has further reduced the advantage provided by relative price control with respect to raw materials previously enjoyed by pulp mills.

In the past, the decentralized structure of the industry had acted to increase supply of wood at each cyclical increase in demand, and for slight or no price increase. Over capacity in lumbering was endemic, and response to demand immediate. To that structural advantage, the pulping industry added political pressure on the Forest Service, ownership of timberland, integration, utilization of residues, and control of the access of small wood lot owners to markets as institutional mechanisms to promote control of raw materials costs. Above all, constantly growing markets permitted the industry to install increasingly larger plants, increasingly faster paper machines. The practical consequence was that fixed--and thus apparently controlled--capital costs have become an increasingly larger share of the total cost of the product; while inherently less controllable raw materials costs were relatively de-emphasized. Cost control was primarily a matter of sustaining a high volume of output per unit of capital.

The strategy served the industry well when demand was rising. There are growing signs of discomfort with it, however. A new generation of forest products managers is finding itself a prisoner of a situation predicated upon the expectation of continuing growth of demand, with volume production an imperative. But production targets have often been achieved without generating either the dollar sales or the profits they were projected to obtain.

Apparent over-capitalization of paper production capacity thus created a high level of fixed costs that must be serviced by volume production; and that led to recurring periods of market saturation and depressed sales prices at the same time that it reduced the raw materials base. Reduced availability of raw materials created upward pressure on their prices.

Paper producers, caught in the noose of over-production, have had difficulty passing such cost increases forward. It is a cycle that the major firms appear to be trying to break, cutting back paper production by closing less profitable mills. (The trend is industry-wide, and not a Region X phenomenon. Much of the retrenchment is taking place under a guide of response to environmental pressures. Industry spokesmen have been quoted in both Paper Mill News and Chemical Engineering as welcoming the influence of environmental protection costs for precisely the reasons indicated above.) Forced to review their capital and production status, managements have taken the opportunity to conduct some fundamental pruning aimed at relieving over-production through elimination of high cost operations. Unstated, but implicit, is the opinion that environmental regulation provides management with a cover to conduct such pruning and at the same time to avoid the onus of consequent unemployment and other frictions by shifting responsibility to the shoulders of government.

In distinction to the trend in pulp and paper, sales prices for lumber have been able to fluctuate in direct response to stumpage prices and to sustain profitable mark-ups. Historical relationships have been reversed, in large degree as a consequence of the integration of forest products production in the hands of fewer and stronger firms. Now it is pulp and paper production that suffers from over-capacity and an inability to pass on higher raw materials prices, where formerly it was the small lumberman who was in excess supply. Increasing scarcity of logs and a reduced number of producers has strengthened the ability of the lumber industry to pass on and markup raw materials costs, even while constant pressure is exerted on paper prices by industry over capacity. In recent periods of buoyant construction, lumber and plywood prices have moved sharply upward, pulling wood costs with them. (cf. Table 5) Paper industry profits were concurrently depressed as a result of competition with lumber for raw materials and general over capacity.

The shift in relative advantage cannot have been unnoticed by management. The incentive to cut a tree early in order to turn it into pulp is progressively reduced as the profit on that tree's fibre yield sinks below the discounted profit to be gained by letting it grow another five years and turning it into two by fours. The net rate of return on the added growth has been rising relative to the compounded profit to be anticipated from early pulping. Indeed, forest products firms are finding with increasing frequency that they lose money by pulping their potential lumber and plywood supplies.

In short, the increasing cost of wood, the growing scarcity of sawtimber, the perennial over-production of paper, and the increasing integration of forest products firms would all seem to argue against sustaining the trend that has emphasized production

Table 5

AVERAGE STUMPAGE PRICES

SAWTIMBER SOLD FROM NATIONAL FORESTS

	Dollars per thousand board feet			Percent of 1960		
Year	Douglas Fir	Western Hemlock	Ponderosa Pine	Douglas Fir	Western Hemlock	Ponderosa Pine
1960	6.40	2.10	18.60	100	100	100
1961	5.40	2.20	7.70	84	105	41
1962	5.70	2.10	11.60	89	100	62
1963	7.60	4.60	11.30	119	219	61
1964	10.60	5.50	16.00	166	262	86
1965	9.20	7.10	14.00	44	338	75
1966	10.30	7.20	13.50	61	343	73
1967	10.80	5.20	11.00	169	248	59
1968	26.90	27.40	35.80	420	1305	192
1969	25.40	26.30	41.90	397	1252	225
1970	7.50	1.70	19.10	117	81	103
1971	10.10	2.90	11.20	158	138	60

of paper at the expense of lumber and plywood. In the future, Region X may anticipate more balanced operation of the various sectors of the forest products industries, within the limits of the natural resource. While total employment opportunities provided by that kind of equilibrium will depend on the balance of demand and the relative productivity rates in the separate sectors, one may conclude--particularly in view of the nearness of the ultimate limits of the raw materials supply--that there will be at least a relative reduction in pulp and paper employment in the future.

Trends, 1963-1972

The net result of the various influences that bear on the regional wood pulping industry has been a drastic reshuffling of its components with respect to location, product mix, gross size, production processes, and productivity. Region X's pulp and paper industry will be very differently composed as it enters 1973 than the industry of a decade earlier.

Locational patterns have shifted significantly, the nature of the shift corresponding generally to the distribution of wood supplies Puget Sound, the leading pulp producing area of 1963, has slipped behind the lower Columbia River area in production, and is only slightly ahead of the Willamette River Valley where productive capacity has almost doubled over the course of the decade.

The southward shift of the focus of production could be seen, too, in the relative ten year growth of capacity at Oregon and at Washington coastal plants The two dissolving pulp mills on Grays Harbor, Washington, added about 150 tons per day to capacity. In comparison, a new kraft mill was brought on stream at Gardiner on the southern Oregon coast and subsequently doubled its capacity to 600 tons per day during the decade, while an existing mill at nearby Toledo was adding 400 tons per day to capacity.

Both the Oregon coast and the Willamette Valley expansion can be interpreted to reflect the intensifying exploitation of the forest resources of southwestern Oregon. The Willamette basin's growth was concentrated in the lower half of the valley, more than 80% of its new capacity occurring as a new 300 ton per day at Halsey and incremental additions of 700 tons per day at an existing mill at Springfield, and another mill in Albany. In sum, half of the total growth of Region X's pulp and paper industry was fueled by logging in southwest Oregon.

East of the Cascades, growth was probably retarded by a continued westward pattern of raw materials movement, but was significant. Sulfate pulp mills at Wallula, Washington, and Lewiston, Idaho, each added about 300 tons per day to capacity. Outside the regional boundaries, but drawing on elements of the same wood supply, the Waldorf Hoerner plant at Missoula, Montana,

augmented output by some 400 tons per day. The shift in location of the industry tended, then, to be eastward to scattered but still relatively abundant wood supplies, as well as southward. (cf. Table 6)

Productive units grew larger through the decade. While gross capacity increased by a third, there was one less pulp mill operating at the decade's end than at its beginning, and three less factory complexes producing pulp. Average capacity per establishment increased very nearly 50%. Three new factories come on stream, at Gardiner, at Halsey, and at Wauna, all in Oregon. Three others closed, one announced an impending closure, and one paper mill discontinued production of pulp, all in the State of Washington--at Port Angeles, at Everett, at Longview, and at Vancouver. (In the interest of clarity, it should be noted that the presence of more than one pulp mill at a factory site is not uncommon. For the purposes of this discussion, each of the specific production processes present at a location is considered to constitute a pulp mill. Thus, for example, Crown Zellerbach's factory complex at Wauna, Oregon, includes a groundwood mill and a sulfate mill.)

Changes in product mix generated by the evolution of demand patterns and by changes in pulping technology were at least as significant as the magnet exerted by raw materials supplies in altering the makeup of the industry.

While capacity to produce all grades of pulp increased during the decade, the increase was very unevenly distributed. Two thirds of incremental capacity was installed in mills producing packaging products. (It was probably the expansion of demand for packaging more than any other factor that promoted the growth of pulping in southwestern Oregon. Douglas fir does not produce a good grade of pulp, but high quality is less important to packaging pulps than are toughness and volume. Vast quantities of Douglas fir residuals generated by Southern Oregon's lumber and plywood expansion proved to be an ideal raw materials base for precisely the kind of pulps that experienced the most vigorous demand growth during the nineteen-sixties.)

Dissolving pulps, the highest quality products and the most demanding in terms of raw materials controls and processing steps, have been a speciality of the Region for four decades. Based on northern Washington hemlock and Alaskan spruce, dissolving pulp production has been responsible for the Region's high proportion of sulfite pulp mills; and the cyclical shifts in demand occurring in chemical markets have keyed the commercial

fortunes of northern Washington communities since the nineteen-thirties to a larger extent than any factor other than the operations of the Boeing Company. Yet in spite of the significance of the product to the regional economy, it is difficult to determine the current trend of production.

During the decade, production of dissolving pulps increased healthily, if not spectacularly. The pronounced depression in demand that coal and petroleum based synthetic materials imposed on cellophane and rayon products finally worked itself out in the late nineteen-fifties, and demand for dissolving pulps began to rise. Between 1963 and 1972, productive capacity moved gradually upward in Region X, and current capacity of 3,055 tons per day is more than 20% greater than the level, roughly double the 1958 low point in the fortunes of the industry when the Rayonier Mill at Shelton was closed, other mills were working well below capacity, and the new Alaskan mills had begun their operations with deficits.

But the apparent return to health of the dissolving pulp industry is, from the regional standpoint, uncertain. Between 1963 and 1972 existing mills added 580 tons to daily productive capacity, more than ten percent of the industry's regional tonnage increment and a larger share than any product component other than packaging. But more than half of that growth is to be cancelled by the announced closure in the spring of 1974 of Weyerhaeuser's Everett sulfite mills. That closure will continue the long term relative decline of Region X dissolving pulp output.

While markets and profit margins for chemical grade pulps seem secure, advances in sulfate pulping and bleaching technology would seem to be counteracting the advantage in raw material quality that has allowed Region X to dominate dissolving pulp production. The Weyerhaeuser closure amounts to a transfer of production to a new sulfate mill at New Bern, North Carolina, one that is closer to east coast and European markets that take the bulk of output. Given the technology for production of dissolving pulps from inferior raw materials by the sulfate process, the significance of transportation costs, and the enormous importance of economies of scale in pulp production, it would seem distinctly possible that one or two east coast mills could prempt domestic markets for dissolving pulp within the next decade, and that they could also make considerable inroads on the significant export market--which is largely European for Washington, Japanese for Alaskan mills. Whether Washington's dissolving pulp industry can survive without significant consolidation is beginning to be a valid question.

Table 6
Capacity & Location of Pulp Mills, 1963-1972

	Aggregate 24hr. capacity, tons		shift	
	1963	1972	tons	percent
Alaska	1,050	1,355	+305	+29%
Puget Sound*	4,430	4,219	-211	- 5%
Washington Coast	750	904	+154	+21%
Lower Columbia	4,380	5,644	+1,259	+29%
Oregon Coast	815	1,750	+935	+115%
Willamette	2,035	3,878	+1,843	+91%
Upper Columbia	1,160	1,732	+572	+49%
Region X Total*	14,620	19,482	+4,862	+33%
	Number of Mills & (Establishments)**			
Alaska	2 (2)	2 (2)	-	-
Puget Sound*	16 (12)	12 (9)	-4	-25%
Washington Coast	2 (2)	2 (2)	-	-
Lower Columbia	10 (7)	10 (5)	-	-
Oregon Coast	3 (3)	3 (3)	-	-
Willamette	9 (7)	11 (8)	+2	+22%
Upper Columbia	4 (3)	4 (3)	-	-
Region X Total*	46 (36)	44 (32)	-2	2%
	Mean Daily Capacity Per Establishment (tons)			
Alaska	525	673	+148	+28%
Puget Sound*	369	469	+100	+27%
Washington Coast	375	452	+77	+20%
Lower Columbia	626	1,129	+503	+80%
Oregon Coast	272	583	+311	+114%
Willamette	291	485	+194	+67%
Upper Columbia	387	577	+190	+49%
Region X Total*	406	609	+203	+50%

* Excludes both Simpson Lee and Weyerhaeuser sulfite, Everett for 1972

** A mill is considered to be a facility that produces pulp by a given process. An establishment is considered to be one or more pulp mills at a given site. (e.g., Publishers Paper Co. at Oregon City is viewed as an establishment consisting of a sulfite and groundwood mill.)

The general purpose pulp mills that dominated the output of the Region in 1963 have lost considerable ground in a relative sense in the last few years. Specialized production in progressively eating into the range of products produced at any pulping establishment. It has been found that variable final product requirements can be met by inter-plant exchanges and by keeping each mill within a rather narrow range of production almost as conveniently, and at lower cost, as they can by adjusting outputs internally.

In general, the comparative decline in general purpose pulping has not involved either plant closures or reduction of output. Instead, there has been a progressive sharpening and specialization of the production focus in existing mills. One aspect of the shift, then, has been an apparent increase in the relative output of groundwood production and discontinuing production of chemical pulp at several general purpose mills. Small general purpose plants employing both a chemical and groundwood process have become groundwood mills only. (In distinction, one massive sulfate/ groundwood complex was initiated at Wauna on the lower Columbia; and the two rather small Publishers Paper mills were expanded significantly--from a total capacity of 300 tons per day of groundwood and 270 tons per day of chemical pulps to 695 tons per day of goundwood and 399 tons per day of chemical pulps.)

The trend in general pupose pulp production seems very clear. The number of plants is shrinking--six of them disappeared, either through closure or by relegation to specialized production, between 1963 and 1972. Their size is increasing markedly: between 1963 and 1972, average daily capacity of general purpose pulp plants rose from 411 tons per day to 632 tons per day. A lesser number of larger plants, each somewhat more specialized than before, is sustaining production of the full range of pulp grades, and depending on purchase and internal transactions to provide the demanded range of final products. At this point in time, only one paper mill, Boise Cascade at Vancouver, Washington, is in operation without pulping capacity at the same site. (The pulp mill was closed during the decade.) But as specialized pulp mills become more prevalent, it is not unlikely that other paper machines will remain operational in spite of elimination of an obsolete pulp mill, or one whose raw material supply is insufficient to permit expansion.

Production process mix proved to be very sensitive to the change in product mix. In 1963, sulfate pulping already constituted the largest block of processing capacity in the region. In the next ten years, eighty percent of the gross shift of industry capacity was in the form of addition to sulfate pulping; so that the sulfate process now accounts for well over half of total regional capacity.

In some degree, sulfate pulping growth was due to a broadening participation in markets for general purpose pulps (e.g., expansion at Boise Cascade's St. Helens' plant and installation of the Crown Zellerbach plant at Wauna). In such cases, ability to deal with resinous Douglas fir, the predominant wood species, and advantages with respect to control of water pollution may be considered to have dictated the use of the process. But to a very considerable extent, the use of the sulfate process was a function of the growth of packaging markets, where sulfate pulps have been dominant since the nineteen-twenties.

Growth of packaging markets is also responsible for the vigorous--more than 100%--expansion of semi-chemical pulping capacity. Although there is only one exclusively NSSC mill in the region, five paperboard plants include NSSC mills. (The predominant output of such mills is the corrugating medium that is commonly sandwiched between kraft board walls in heavy duty paper boxes.)

Capacity to produce sulfite pulps was almost static over the period, if allowance is made for the impending closure of the Weyerhaeuser mill at Everett. Unfavorable unit costs and water pollution control difficulties as compared to the sulfate process probably combined in equal measure to retard growth of sulfite pulping. But within the group of mills using the process, major changes took place. Mills were closed at Port Angeles, Millwood, and Vancouver, Washington, and at West Linn, Oregon. Of the remaining mills, all but one abandoned calcium sulfite pulping and converted to one of the recoverable chemical bases--magnesium, soda, or ammonia. Though the conversion may be considered to have reduced the unfavorable unit production cost gap with sulfate pulps of an equal grade, there can be little question that the conversions were in every case to be attributed to water pollution control regulations. Significantly, three of the four plants that were closed rather than converted had a capacity to produce less than one hundred tons of pulp per day, and all were associated with a groundwood mill. Their closures, then, accommodate to the pattern of specialization in larger productive units, with water pollution control considerations playing a contributory role in the adjustment decision.

Groundwood production, too, was marked by a static aggregate situation with considerable reshuffling of constituents. Three small mills were closed in Washington, and production was reduced at a fourth. Two large (290 tons per day) mills were opened in Oregon, and production was reduced at a third. The shifts were associated in large measure with Crown Zellerbach Company, which reduced its penetration of groundwood markets substantially to concentrate on the growth opportunities to be found in packaging.

Crown Zellerbach Groundwood Mills
Daily Production Capacity, tons

	1963	1972
West Linn	385	180
Port Angeles	410	266
Camas	90	---
Wauna	---	298
TOTAL	885	744
Percent of Region Total	54%	43%

The slack that resulted from Crown Zellerbach's partial withdrawal was more than taken up by Publishers Paper Company's installation of a groundwood mill at the site of an acquired sulfite mill at Newberg, Oregon. By increasing groundwood capacity from 300 tons to 695 tons per day, the smaller firm achieved near parity with Crown Zellerbach in markets utilizing groundwood pulp. Acquisition and internal expansion of sulfite pulping brought Publishers Paper's total capacity from 420 to 1,094 tons per day, gave the firm tight internal control of pulp output, and made it a significant factor in western markets for newsprint and speciality papers.

Employment & Productivity

Changes that Region X pulping has experienced over the last decade have not exercised any significant aggregate impact on labor markets. Gross capacity and output have increased vigorously enough to obscure the effects on productivity of fewer and larger plants. Local gains in areas of expansion have tended to cancel out losses in areas of contraction or improved efficiency. There has been localized hardship (the more severe because it was concentrated in the general area of northwestern Washington State, where other elements of the regional economic base were undergoing simultaneous contraction of employment opportunities). There has been localized boom. But the overall effect of the industry's development on the regional employment pattern was slight. Through an initial period of vigorous expansion that ended in 1967-68, the industry's employment requirements increased about ten percent, just about stabilizing its share of regional employment. Since that time, employment has been declining, gradually, but inexorably.

Productivity, measured in terms of capacity per unit of employment, increased by a third in the course of the decade. The gain was greatest, as was growth of capacity, in the first half of the period, when total capacity increased about ten percent faster than productivity. Since 1967, however, productivity has risen almost twice as fast as capacity--hence, a decline in employment.

As might be anticipated, productivity increase has been most rapid in Oregon, where the bulk of investment took place in 1963-1972. Capacity per worker rose almost 80 percent as total capacity rose 130 percent. And by the end of the decade, Oregon's labor productivity was within 89 percent of that of Idaho, even though the average age of Oregon plants was more than twice--and the average size little more than half--that of Idaho's only pulp mill.

Table 7
Shifts in Product Mix 1963-1972

Product	State	Establishments 1963	Establishments 1972	Establishments Shift	24 Hour Capacity 1963	24 Hour Capacity 1972	Tons Shift
Packaging & Board	Oregon	4	6	+2	1,375	4,005	+2,630
	Washington	2	2	-	1,830	2,516	+ 686
	Region X	6	8	+2	3,205	6,521	+3,316
Multi-Grade Chemical Pulp	Oregon	5	3	-2	845	1,149	+ 304
	Washington	10	8	-2	5,405	5,241	- 164
	Idaho	1	1	-	650	1,000	+ 350
	Region X	16	12	-4	6,900	7,390	+ 490
Chemical Plus Groundwood Pulp	Oregon	2	3	+1	1,005	2,097	+1,092
	Washington	3	0	-3	735	0	- 735
	Region X	5	3	-2	1,740	2,097	+ 357
Groundwood	Oregon	0	1	+1	0	180	+ 180
	Washington	2	3	+1	230	552	+ 322
	Region X	2	4	+2	230	732	+ 502
Dissolving Pulp	Alaska	2	2	-	1,050	1,355	+ 305
	Washington	4	3	-1	1,425	1,390	- 35
	Region X	6	5	-1	2,475	2,745	+ 270
All Products					14,550	19,485	+4,935

Percent of Capacity	1963	1972
Packaging & Board	22%	33%
Multi-Grade Chemical	47%	38%
Chemical-Groundwood	12%	11%
Groundwood	2%	4%
Dissolving Pulp	17%	14%

Percent of Net Capacity Increase	
Packaging & Board	67%
Multi-Grade Chemical	10%
Chemical-Groundwood	7%
Groundwood	10%
Dissolving Pulp	5%

Table 8
Shift in Process Mix
1963-1972

PULPING PROCESS	STATE	MILLS 1963	MILLS 1972	MILLS SHIFT	24 HOUR CAPACITY, TONS 1963	24 HOUR CAPACITY, TONS 1972	24 HOUR CAPACITY, TONS SHIFT
SULFATE	Idaho	1	1	--	650	1000	+ 350
	Oregon	4	7	+3	1625	5160	+3535
	Washington	8	7	-1	4505	4805	+ 300
	REGION X	13	15	+2	6780	10,965	+4185
CALCIUM SULPHITE	Oregon	6	--	-6	790	--	- 790
	Washington	11	1	-10	3105	527	-2578
	REGION X	17	1	-16	3895	527	-3368
OTHER SULPHITE	Alaska	2	2	--	1050	1355	+ 305
	Oregon	--	4	+4	--	748	+ 748
	Washington	2	8	+6	750	3359	+2609
	REGION X	4	14	+10	1800	5462	+3662
GROUNDWOOD	Oregon	2	4	+2	685	1173	+488
	Washington	7	4	-3	945	574	-371
	REGION X	9	8	-1	1630	1747	+117
NSSC	Oregon	1	2	+1	125	350	225
	Washington	3	6	+3	325	744	+419
	REGION X	4	8	+4	450	1094	+644

PERCENT OF CAPACITY	1963	1972
Sulfate	47%	55%
Calcium sulfite	27%	3%
Other sulfite	12%	28%
Groundwood	11%	9%
NSSC	3%	6%

PERCENT OF NET CAPACITY SHIFT	
Sulfate	80%
Calcium Sulfite	-64%
Other Sulfite	70%
Sulfite, all types	6%
Groundwood	2%
NSSC	12%

In Washington, which has historically provided the bulk of the area's employment in pulping, productivity increase was slower and more painful. Without the assistance of material new investments, the state's industry dragged its productivity tortuously upward by minor (in comparison with the massive reworking of the Oregon industry) capital improvements to existing plants and by accepting the trauma of closure of the three old plants. Labor productivity in the Washington segment of the industry; 114 percent of Oregon's, at the beginning of the decade, had fallen to 71 percent of Oregon's by the end of the period.

In total, the substitution of capital for labor reduced aggregate employment opportunities in Region X by 9,000 to 10,000 jobs, depending upon whether one uses regional or individual State capacity to employment ratios to assess the number of jobs that might have been available in the absence of productivity improvements. Fortunately, increased output was sufficient to hold actual reduction of jobs to just over 1,000.

The fact must be faced that productivity improvements will continue to take place; and that raw materials are not available to sustain sufficient expansion to offset its employment retarding effects. During 1972, elimination of another 1,100 jobs by closure of two Everett, Washington, mills was announced. Since the gross ratio of employment to capacity of the mills was almost precisely that of all Washington mills, no indicated improvement in Washington's lagging productivity occurred.

The difference in labor costs imposed by the differences in productivity of the Washington and Oregon segments of the industry amounts to more than $3.50 per ton of product. The difference traces, obviously enough, not to differences in the quality of either State's labor force, but to the effective capitalization commanded by the worker in either State. As the relative capital deficiency of Washington mills is supplied in the future, employment will drop in the absence of offsetting increases in output; and forces that act to increase the rate of investment will accelerate the pace of employment loss.

Given static production capacity, Washington will lose up to 5,000 jobs in pulp and paper if the industry moves up to the efficiency standard of its southern neighbor.

Also in a situation of production parity, Washington would lose 6,000 jobs, Oregon 1,000 jobs by achieving the level of labor productivity of the one mill in Idaho.

TABLE 9
EMPLOYMENT & PRODUCTIVITY
TRENDS

	1963	1967	1971
OREGON			
No. of Establishments	11	12	13
Mean Age (years)	38.1	35.1	32.2
Gross Capacity (tons/day)	3225	6195	7431
Gross Employment	7200	8500	9200
Mean Capacity	293	516	572
Mean Employment	655	708	708
Mean Employment per ton	2.23	1.37	1.24
WASHINGTON			
No. of Establishments	21	20	18
Mean Age (years)	37.7	41.7	45.1
Gross Capacity (tons/day)	9630	10499	10182
Gross Employment	18800	19900	17700
Mean Capacity	459	522	566
Mean Employment	895	995	983
Mean Employment per ton	1.95	1.90	1.74
IDAHO			
No. of Establishments	1	1	1
Mean Age (years)	7	11	15
Gross Capacity (tons/day)	650	769	1000
Gross Employment	900	900	1100
Mean Capacity	650	769	1000
Mean Employment	900	900	1100
Mean Employment per ton	1.38	1.17	1.10

Taking raw material considerations into account, the real world situation is apt to be even harsher. Growth prospects are limited, but there is no reason to assume that existing Idaho employment to capacity levels represent any ceiling on labor productivity. Since the obvious means to reduce labor costs is to replace small, old plants with adequately capitalized plants, and since raw material supplies may be more promising elsewhere, northwestern Oregon and western Washington may anticipate significant employment loss in the pulp and paper industry over the course of the next few years.

Appendix

Mr. Ralph Scott, Chief, Paper and Forest Industries Research, National Waste Treatment Research Program, in reviewing this study has called attention to longer term factors that have the ability to modify the conclusions that may be drawn from the foregoing materials. His remarks are included here because of their pertinence and because of Mr. Scott's really extraordinary knowledge of the industry. The analyst is forced to note, however, that raw material factors based on recycling and alternate material sources are at least as apt to retard as to foster relative growth in Region X. Nor should log exports be considered in isolation as an influence on growth prospects, in that net materials flows for raw wood, lumber, pulp and paper between the U. S., Canada, and Japan is the significant variable. Thus the shift to Canada of the U. S. export market for logs, if balanced by an equal reduction of wood imports from Canada, would result in an equilibrium with respect to raw materials that could easily damage U. S. producers--particularly in the logging industry--by limiting their flexibility in production and marketing.

Mr. Scott's comments follow.

> While not directly pertinent to immediate mill closure possibilities, the report contains assumptions concerning future development of increased production in the Northwest. One concludes, from this information, that production capacity is not likely to show significant growth--this derived from statistics on available wood supply and competition by lumber and plywood. Several possibilities make any firm conclusion unlikely. Briefly, these are as follows:
> a. Present and coming restraints on slash burning suggest this fiber tonnage, formerly left in the woods and destroyed, must now find other avenues of disposal. For years the Forest Service has pointed to added fiber tonnage in this fraction of the tree. With burning prohibited and increased fiber costs, it seems likely that a large share of this raw material source will be salvaged as chips available for added pulp production.

b. There is a world-wide competition for fiber among industrialized countries. European and U.S. companies are moving into tropical hardwoods and bamboo--as is Japan. Much research, even at OSU, is being directed at fiber sources other than wood. Principally these sources are bagasse (cane sugar), rice straw, and wheat straw. One principal hurdle preventing use of such materials is the seasonal supply for a year-round industry. Storage losses and deterioration may eventually be solved. Cereal or seed straw could well provide added fiber tonnage to the Northwest industry. It is estimated that 50 million bone dry metric tons of wheat straw are available in the U.S. alone. The Agricultural Economics Department at OSU estimates there are 1.5 million tons of grain and seed straw available in the Willamette Valley.

c. There is a growing world-wide tonnage of synthetic fiber from petrochemicals. This is principally now in Europe and in Japan. Crown Zellerbach has patent rights from Japanese sources--but does not evidently consider the process economically feasible today--which is only to say wood fiber is presently cheaper. The future potential is nonetheless a reality.

d. Recycled fibers, while not a new source, looms larger as increasing percentages of used fiber are required in product lines.

e. We cannot discount the hardwood reserves represented by oak, maple, and alder in the Northwest. These can be handled by some modified sulfate processes and are especially adaptable to neutral sulfite semichemical pulping. For example, Georgia Pacific at Toledo will add 150 T/D neutral sulfite pulping of unbarked alder--suitable pulp for their product. The potential for NSSC pulping in the Northwest is significant.

f. Chip and log exports from the Northwest must be considered. The second quarter report (1972) on the Northwest forest industries, Forest Service, shows chip shipment of 460,000 short tons from the Oregon customs district and 29,000 tons from the Washington district. This tonnage could be processed to pulp in the Northwest. Hardwood log exports from Oregon and Washington were 2.4 million board feet in the second quarter. Softwood log exports totalled 708 million board feet for the same period. In conclusion, future growth in pulp and paper production in the Pacific Northwest can be significant.

II. WASTE PRODUCTION FACTORS

There were thirty-four pulp and/or paper manufacturing establishments active in Region X in June 1972. Those plants--which do not include wet process hardboard, felting, or paper converting establishments not associated with a paper mill--supported an aggregate daily production capacity of well over 19,000 tons of pulp. They also discharged, according to data reported by the mills themselves, almost a billion gallons of waste a day, close to three times that discharged by the sewered population of the four state area and far more than the total discharged by all other manufacturing establishments in the Region. The oxygen demanding strength of those wastes, after treatment, was roughly equal to that of the untreated wastes of 21 million people--about eight times the strength of the total waste discharge, after treatment, of the sewered population of Region X--or almost 40% of that of the total sewered population of the United States. (Table 10)

The production and waste discharge characteristics of the industry are distributed without apparent pattern through the region and between establishments, one seeming to have little proportional relationship to the other. Obviously, gross production of woodpulp is an indifferent guide to waste discharges of pulping.

	Percent of Regional Total			
Sub-Area	Pulp Production	Waste-Water	BOD	Solids
Alaska	6.8	9.7	11.0	12.0
Puget Sound	23.6	28.9	55.1	20.8
Washington Coast	4.5	6.6	12.0	2.9
Oregon Coast	8.8	2.9	2.0	3.9
Lower Columbia	28.3	35.1	15.8	51.0
Willamette	19.4	12.5	1.2	4.9
Upper Columbia	8.7	4.2	3.0	4.3

Table 10
Capacity and After Treatment Waste Discharge
of Region X Pulp and Paper Mills

FIRM	LOCATION	24 hour capacity	24 hour waste discharge		
			Flow (G)	BOD (lbs)	Solids (lbs)
Alaska Lumber & Pulp	Sitka, AK	725 Mg	43,500,000	274,000	102,000
Ketchikan Pulp	Ketchikan, AK	630 Mg	52,900,000	112,000	53,700
	ALASKA	1355	96,400,000	386,000	155,700
Boise Cascade	Steilacoom, WA	220 G	6,000,000	9,700	11,200
Crown Zellerbach	Port Angeles, WA	266 G	11,900,000	172,000	46,300
	Port Townsend, WA	405 S	16,300,000	15,800	6,960
Georgia Pacific	Bellingham, WA	527 Ca	52,500,000	132,000	43,100
		45 N			
ITT Rayonier	Port Angeles, WA	486 Am	34,500,000	537,000	38,800
St. Regis	Tacoma, WA	887 S	30,400,000	61,100	13,300
Scott Paper	Anacortes, WA	140 Am	9,100,000	114,000	7,850
	Everett, WA	814 Am	59,100,000	576,000	27,600
		22 G			
Simpson-Lee	Everett, WA	173 S	9,100,000	15,800	38,640
Weyerhaeuser	Everett, WA	410 S	31,100,000	23,200	19,900
	Everett, WA	310 Am	27,700,000	278,000	16,300
	PUGET SOUND	4705	287,700,000	1,934.600	269,950
ITT Rayonier	Hoquiam, WA	504 So	36,700,000	317,000	29,400
Weyerhaeuser	Cosmopolis, WA	400 Mg	29,400,000	104,000	8,830
	WASHINGTON COAST	904	66,100,000	421,000	38,230
Georgia Pacific	Toledo, OR	1000 S	13,000,000	30,300	20,800
International Paper	Gardiner, OR	600 S	14,000,000	25,500	20,500
Menasha	North Bend, OR	150 N	2,230,000	13,500	9,240
	OREGON COAST	1750	29,230,000	69,300	50,540
Boise Cascade	St. Helens, OR	800 S	32,200,000	24,800	22,700
Crown Zellerbach	Wauna, OR	705 S	53,300,000	71,100	20,700
		298 G			
	Camas, WA	730 S	104,000,000	172,000	46,300
		415 Mg			
Longview Fibre	Longview, WA	1600 S	61,400,000	107,000	64,000
		250 N			
Weyerhaeuser	Longview, WA	331 S			
		290 Mg	98,500,000	181,000	508,000
		225 N			
	LOWER COLUMBIA	5644	349,400,000	555,900	661,700
American Can	Halsey, OR	330 S	13,400,000	1,340	1,780
Boise Cascade	Salem, OR	250 Am	19,200,000	8,010	3,710
Crown Zellerbach	Lebanon, OR	99 Am	5,250,000	5,280	2,945
	West Linn, OR	180 G	22,100,000	7,100	32,900
Publishers Paper	Newberg, OR	210 Mg	10,400,000	6,095	7,910
		290 G			
	Oregon City, OR	189 Mg	30,900,000	8,460	6,980
		405 G			
Western Kraft	Albany, OR	570 S	6,200,000	2,380	1,180
		200 N			
Weyerhaeuser	Springfield, OR	1155 S	17,000,000	2,660	6,660
	WILLAMETTE	3878	124,450,000	41,325	64,065
Boise Cascade	Wallula, WA	442 S	7,000,000	22,600	16,900
		224 N			
Inland Empire	Millwood, WA	66 G	3,110,000	5,560	849
Potlatch Forest	Lewiston, ID	1000 S	32,200,000	77,700	38,400
	UPPER COLUMBIA	1732	42,310,000	105,860	56,149
	REGION X	19,968	995,590,000	3,513,985	1,296,334

Mg = Magnesium base sulfite pulp
G = Groundwood pulp
S = Sulfate pulp
Ca = Calcium base sulfite pulp
N = Semichemical pulp
Am = Ammonia base sulfite pulp
So = Soda base sulfite pulp

Table 11
Effluent Characteristics
Northwest Pulp & Paper Mills

FIRM	LOCATION	DISCHARGE PER TON OF PULP			MILLIGRAMS/LITER	
		Flow	BOD	Solids	BOD	Solids
1. NO WASTE CONTROLS						
Georgia Pacific*	Bellingham, WA	91,800	230	75	300	115
ITT Rayonier	Port Angeles, WA	71,000	1105	80	1870	135
2. EVAPORATION OF PULPING LIQUORS						
Georgia Pacific	Toledo, OR	13,000	30	21	280	195
Crown Zellerbach	Port Townsend, WA	40,200	39	17	115	50
Simpson-Lee	Everett, WA	52,600	91	223	210	510
Weyerhaueser	Everett, WA	75,900	57	49	90	80
Alaska Lumber & Pulp	Ketchikan, AK	60,000	378	141	755	280
Ketchikan Pulp	Ketchikan, AK	84,000	178	85	255	120
3. SEDIMENTATION ONLY CONTROL						
Scott Paper	Anacortes, WA	65,000	814	56	1505	105
Scott Paper	Everett, WA	70,700	689	33	1170	55
Weyerhaueser	Everett, WA	89,400	897	53	1205	70
4. EVAPORATION & SEDIMENTATION PROVIDED						
Potlatch Forest	Lewiston, ID	32,200	78	38	290	140
International Paper	Gardiner, OR	23,300	43	34	220	175
St. Regis Paper	Tacoma, WA	34,300	69	15	240	55
ITT Rayonier	Hoquiam, WA	72,800	629	58	1040	95
Crown Zellerbach	Wauna, OR	53,100	71	21	160	50
Boise Cascade	Wallula, WA	10,500	34	25	330	285
Longview Fibre	Longview, WA	33,200	58	35	210	125
Weyerhaueser	Longview, WA	116,400	214	600	220	620
Crown Zellerbach	Camas, WA	90,800	150	40	200	55
5. GROUNDWOOD MILLS, SEDIMENTATION ONLY CONTROL						
Boise Cascade	Steilacoom, WA	27,300	44	51	195	225
Crown Zellerbach	Port Angeles, WA	44,700	44	83	120	225
Menasha	North Bend, OR	14,900	90	62	726	500
Inland Empire	Millwood, WA	47,100	84	13	215	35
6. STABILIZATION, AFTER PRIOR TREATMENT						
Crown Zellerbach	West Linn, OR	122,800	39	183	40	180
American Can	Halsey, OR	40,600	4	5	12	15
Boise Cascade	St. Helens, OR	40,300	31	28	90	85
Weyerhaueser	Springfield, OR	14,700	2	6	16	50
Boise Cascade	Salem, OR	76,800	32	15	50	25
Crown Zellerbach	Lebanon, OR	53,000	53	30	120	70
Weyerhaueser	Cosmopolis, WA	73,500	260	22	425	35
Publisher's Paper	Newberg, OR	20,800	12	16	70	90
Publisher's Paper	Oregon City, OR	52,100	14	14	30	30
Western Kraft	Albany, OR	8,100	3	7	45	105

*By-product recovery is practiced, but effect is less than evaporation of pulping liquors.

It is an article of faith even more than a technical evaluation that waste treatment is one of the influences that account for variability in the production/waste discharge relationship. The data support that faith, in that waste strength per unit of production--more precisely, strength per ton of 24 hour rated capacity--declines progressively with the degree of waste treatment currently available, as indicated by mean waste to product values of the mills grouped by waste reduction practices:

Waste Reduction Practices	Mean Per-Ton Discharge			Milligrams/Liter	
	Flow (G)	Lbs BOD	Lbs Solids	BOD	Solids
None	71,000	1105	80	1870	135
Sedimentation	75,000	800	47	1293	77
Evaporation of Pulp Liquors	59,600	143	87	286	193
Evaporation and Sedimentation	48,800	127	84	330	178
Stabilization after prior treatment	50,300	45	33	90	69

It is apparent, however, that waste treatment alone does not adequately explain variation in waste loading rates. Solids loadings and concentrations show little apparent variation with treatment in the illustration above, and BOD concentrations for the sample of plants presented in the region behave perversely in the case of the contrast between chemical pulping plants providing evaporation of strong pulping liquors and those which add sedimentation following the evaporation process. The absence of a consistent pattern is even more striking when comparisons are drawn on a plant-by-plant basis rather than in terms of aggregated groups. (Table 11)

Just as prevalence and degree of waste treatment fail to explain adequately all of the water polluting potential of the operations of any particular pulp and paper mill, so does the cliche that "it is the small, old plants that cause the worst problems."

Older plants and smaller plants do tend to discharge more wastewater containing more biochemical oxygen demand and more solids per unit of output than larger or newer mills. (Table 12) But the tendency is not undeviating as one moves in stages from smallest to largest or from oldest to newest. Indeed, Region X mills of less than 300 tons per day capacity, on average, discharge <u>less</u> BOD and solids per ton

Table 12
Waste Characteristics by Categories
of Pulping Activities

Category	Mean Waste Discharge per Ton		
	Flow (G)	BOD (lbs)	Solids (lbs)
1. Product Difference			
Paper grade & dissolving pulps	75,200	398	79
Newsprint	52,500	40	60
Packaging	35,000	49	27
2. Process Differences			
Predominantly sulfite	67,800	407	52
Predominantly sulfate	35,700	47	40
Predominantly groundwood or NSSC	49,400	60	78
3. Age of Plant			
Constructed before 1925	63,200	137	71
Constructed 1925 - 1945	61,900	360	92
Constructed 1946 - 1960	37,000	120	43
Constructed after 1960	39,000	39	20
4. Size of Plant			
Less than 300 T/D	54,400	133	53
300 - 500 T/D	65,300	391	57
501 - 800 T/D	36,400	51	32
Greater than 800 T/D	46,000	151	96
5. ALL PLANTS	54,100	202	68

of output than do mills larger than 800 tons per day. And while mills built since 1960, i.e., mills put in place when concern for water pollution control was high and was represented by vigorous state regulatory programs, discharge far less wastes per unit of output than older plants, the oldest class of mills, those initially installed in 1925 or earlier, manifest distinctly less wastes per ton than mills built in the period 1926-45, and are not very different in waste/output relationships than post World War II mills installed prior to 1961.

More significant than age of plant, size of plant, or even level of waste treatment are basic product and production process distinctions. Waste per unit of output levels are roughly an order of magnitude greater for plants producing high grade pulps and for plants producing by the sulfite process (they are, of course, pretty much the same plants) than for others. Indeed, it is a recapitulation of those fundamental market-technology interactions that seems to produce such meaningful distinctions as one may find in the age and size differences. The oldest and the smallest mills in Region X tend to be groundwood mills. Sulfite mills cluster in the 300 to 500 ton per day range; and it was market conditions of the late twenties and the thirties that produced the heyday of sulfite pulping.

To understand the pollutional aspects of pulp and paper production as they relate to water, it is necessary, then, to examine processing and waste treatment technology, the activities that produce wastes and reduce their polluting effects.

If one strips away the accompanying phenomena, such as age and size of plant or tonnage and quality of pulp production, waste discharge per ton of output may be found to correlate rather directly with three factors: (1) efficiency of recovery of pulping chemicals, (2) amount of bleaching, and (3) degree of waste treatment performed.

For all practical purposes, at least when analyzing wastewater, all chemical pulping processes initially produce roughly the same amount of wastes. There are, to be sure, wide absolute variations in strength of wastes that are caused by factors such as length of cook, species of wood pulped, mean age and moisture content of wood pulped, formulation of cooking liquor, employment of mechanical or hydraulic barkers or of purchased wood chips, method of pulp washing, boiler efficiency, operating rate, etc. But those have but slight proportional influence on inter-plant comparisons. All chemical pulping processes do essentially the same thing. In enormous pressure cookers ("digesters") they cook out of wood, with the use of a chemical solution, heat, and pressure, the components of wood fiber that are something other than cellulose in order to separate those components, together with the

cooking chemicals, from the cellulose, which is sprayed in liquid suspension onto a moving belt to be dried into sheets. To produce a ton of wood pulp or of paper—which is little more than a specialized form of pulp, sometimes containing other materials to improve opacity, texture, strength, etc.,--it is necessary to dispose of roughly seventeen tons of water, chemicals, and wood waste products that have been separated from the pulp. Since only about half of the wood that goes into the mill is utilizable as product, each ton of pulp generates another ton of wood waste products, more or less.

By reducing the moisture content of the large share of that wastewater that originates in digestion until it is combustible, burning off the organics, capturing and redissolving the cooking chemicals, most present day pulp plants also eliminate the majority of their waterborne wastes. Since chemical recovery—which is a basic feature of sulfate pulping--is so clearly the key to the industry's water pollution control, most sulfite plants have been forced to abandon calcium sulfite cooking liquors in favor of recoverable bases (magnesium, ammonia, soda) and are no longer necessarily distinguishable in terms of water-borne wastes per unit of product from sulfate mills.

Bleaching carries on the process of separation that begins with digestion of wood fibers into cellulose and non-cellulose components. The limits of purity that apply to digestion are set by the characteristics of wood fibers, and fall well short of requirements for many pulps. In bleaching, "impurities" are dissolved away from the more resistant cellulose to create pulps of higher purity. Those wastes, including the wasted bleaching solutions that carry the wood products, are in many cases substantially stronger than the wastes of pulping, after chemical recovery.

Waste treatment processes applied to pulp mill wastes are modifications of conventional sewage treatment. In general, clarification and stabilization are all that is required to produce an effluent of a quality that matches secondary waste treatment of normal sewage. (Batch processing may sometimes impose a need for equalization; neutralization--particularly of bleach mill wastes--is occasionally demanded; and fertilization is an almost invariable operational requirement to accomplish effective stabilization.) It should be noted, however, that biological treatment of chemical pulping wastes is ineffective--for all practical purposes, impossible--in the absence of chemical recovery or an analogous procedure; unmodified digester waste liquors are too strong and too plentiful to be susceptible to conventional biological treatment methods.

It must be recognized that there is great variability possible in the application and effectiveness of any of the three major determinants of waste strength. The more intensive the pulping cook or the bleach--that is, the higher the quality of pulp produced--the greater the production of wastes. The more complete the collection and combustion of cooking liquors, the less the strength of the waste produced. (Unfortunately, the financially optimum degree of chemical recovery is distinctly below the limits of recovery technology. To achieve an environmentally desirable result, the mill must collect, condense, and incinerate more pulping liquor than it would prefer from the standpoint of the profit and loss statement.)

When aggregated into processing/treatment groupings that reflect those basic distinctions, Region X pulp mills show the dramatic variation that is possible in the production/waste discharge relationship. The most pollutional process combination (no chemical recovery and heavy use of bleaching) produces 280 times as much oxygen demand per ton of product--even with some waste treatment--as does the combination of chemical recovery, minimum bleaching, and maximum employment of waste treatment. (Table 13)

Three Region X mills--American Can at Halsey, Oregon; Weyerhaeuser Company at Springfield, Oregon; and Western Kraft at Albany, Oregon--have often been cited in the technical literature or by environmental interests as outstanding examples of what can be done to reduce water pollutants from pulp and paper production. As Table 13 indicates, those plants are at least a full order of magnitude better in terms of wastes per unit of product than other Region X mills. It is important to note, though, that regardless of the excellence of their waste treatment procedures or the design of the plants to minimize production of water-borne wastes, a significant part of the explanation for their relatively "clean" operations is to be found in their product mix. High yield, coarse, largely unbleached paper board just does not result in the wasting of as much material as does the production of better grades of pulp or paper. It is unreasonable, then, to expect similar levels of waste reduction efficiency from all pulp and paper plants, in the absence of significant modifications in processing technology.

The data submitted through the Waste Discharge Permit system by Region X pulp and paper mills are sufficient to permit the development of an approximate but useful general model of the liquid waste production characteristics of those mills. The relationships were derived by grouping the plants into sets distinguished by common properties and tracing routes between the values of capacity, waste discharge, BOD, and solids for any set and other, different sets to

establish mean production to discharge effects of the significant variables. By no means precise (addition of enough additional variables to improve precision might add little utility), the model does provide an approximate description of the effects of major process variables on waste strength.

The model, whose components are presented in Table 14, provides both fairly reliable means of predicting waste discharges and a useful tool for estimating size, and thus costs, of pollution abatement facilities. Comparison of flow and waste strength values synthesized from the model with reported values suggests that variation in waste production is to some degree explainable in terms of random individual differences between one plant and another, but even more by such quantifiable matters as inputs of purchased pulp; production of products utilizing significant amounts of sizes, pigments, and coatings; and use of hydraulic barkers (which produce significant increases in solids production). Given the necessary information about such matters, the model could probably be used to indicate by a process of elimination, the significant variations in waste discharge that result neither from processing nor from treatment, but from controllable operating and design features. Application of such knowledge could not only significantly reduce waste discharge, but could also reduce the costs of waste treatment.

(N.B. It should be emphasized that all values are provisional, in that they represent a generalization of the existing situation. Thus changes in production processes and controls would impose shifts in the waste production values, and increases in the average efficiency of treatment components--for example, larger treatment plants and detention times--would impose shifts in waste reduction values.)

Table 13
Wastewater Characteristics of Region X Pulp Mills
Grouped by Process/Treatment Classes

24 Hour aggregate characteristics

	Tons of Pulp	Gallons of Wastewater	Lbs of BOD	Lbs of Solids
4 (sulfite) mills, no chemical recovery	1772	130,400,000	1,505,000	90,600
7 (sulfite) mills, w/ chemical recovery & heavy bleaching	3180	239,500,000	952,300	243,600
10 (sulfate) mills, w/ chemical recovery & little bleaching	7541	246,700,000	403,800	262,100
3 showcase mills	2255	36,600,000	6,400	9,700

Mean per ton characteristics

	Gallons of Wastewater	Lbs of BOD	Lbs of Solids
4 (sulfite) mills, no chemical recovery	73,600	849	51
7 (sulfite) mills, w/ chemical recovery & heavy bleaching	75,300	299	77
10 (sulfate) mills, w/ chemical recovery & little bleaching	32,700	54	35
3 showcase mills	16,200	3	4

Percent of Region X Chemical Pulping

	Tons of Pulp	Gallons of Wastewater	Lbs of Solids	Lbs of BOD
4 (sulfite) mills, no chemical recovery	12.0%	20.0%	15.0%	52.5%
7 (sulfite) mills, w/ chemical recovery & heavy bleaching	21.6%	36.7%	40.2%	33.2%
10 (sulfate) mills, w/ chemical recovery & little bleaching	51.1%	37.8%	43.3%	14.1%
3 showcase mills	15.3%	5.6%	1.6%	0.2%

Table 14
General Model of Waste Production
for Woodpulp Mills

	Waste per ton of Product		
	Flow (G)*	BOD (lbs)	Solids (lbs)*
Pulping and Drying	+42,000	+850	+60
process yield miltiplier:			
(dissolving pulp)	1.00	1.00	1.00
(other chemical pulps)	.85	.85	.85
(semichemical pulps)	.65	.65	1.55
(groundwood pulps)	.50	.50	1.90
Heavy bleaching	+32,000	+250	---
Light bleaching	+20,000	+100	---
Strong liquor evaporation	-13,000	-750	-30
Sedimentation**	---	-30%	-45%
Stabilization**	---	-65%	-30%

* strongly affected by barking process
** applied to residual of previous stage

III. WASTE REDUCTION COSTS

Treatment of liquid wastes is not a complex or costly process. For the most part, waste treatment consists of nothing more than introducing water to a vessel that is designed to facilitate natural processes. Those processes--settling, overflow, decomposition--separate water from the introduced materials considered to be pollutants. The latter are drawn off in a thin slurry ('sludge'). The processed water is returned to the natural environment.

Since treatment consists largely of holding water until natural reactions have advanced to some desired point, waste treatment facilities are little more than containment structures--tanks or ditches--linked by pipes, pumps, and valves. Given sufficient holding capacity and appropriate design, a sealed, shallow hole in the ground in which natural life systems develop in response to the characteristics of the water that is introduced can entirely 'purify' a waste stream. In practice, land is seldom available in sufficient quantities at a price that makes such wholly natural treatments advantageous. So capital is supplied in the form of aerators, compressors, digesters, chemical feed devices, pumps, centrifuges, screens, beaters, thickeners to speed up reactions and reduce land requirements.

The state of the art is such that possible trade-offs between land and capital have been reduced to a limited and well-understood series of design alternatives. Basic waste treatment processes consist of a relatively small number of controlled reactions in which land, capital, operating circumstances, and degree of 'purification' can be manipulated with a high probability of success in terms of achieving a predictable design effectiveness at a stipulated cost.

Though a number of variations in technique are possible within the basic land/capital trade-off, the magnitude of costs is determined by three inter-related factors: volume of water to be treated concentration of materials to be reduced, and reaction rates of the materials to be reduced. The design problem is essentially one of determining how much water must be held over how long a time to achieve a desired set of results.

There are definite efficiency plateaux, and marginal costs tend to rise steeply beyond them. As a consequence, waste treatment engineering has been adapted to a modular strategy ('primary,' 'secondary,' and 'tertiary' treatment). When the effective marginal efficiency of one kind of reaction has been achieved, it is less costly to transfer wastes to another kind of specialized vessel in which a separate reaction series is engaged than to in increase the reaction period within a less specialized reactor. The modular strategy is an effort to come to grips with two principles, consecutive and specialized processing of a parcel of water, and speeding the accomplishment of natural reactions that are progressively more difficult to achieve--i.e., naturally slower. Thus each module requires an added reactor, and each reactor tends to be either larger or more capital intensive than the one before. The predictable consequence is that as increasingly higher degree of treatment effectiveness becomes necessary, costs rise more than proportionately. (The rule of thumb is that as each efficiency plateau is attained, costs to reach the next technological plateau will be equal to the sum of all previous costs, for example:

BOD Reduction	Associated Cost
30-40% (primary treatment)	100%
80-90% (secondary treatment)	200%
90-98%	400%
> 98%	800%

Like most rules of thumb, that one is deceptive. It rests on generalizations about the relationship between conventional primary and secondary sewage treatment and some fragmentary data about a series of 'advanced' or specialized waste treatment processes that may or may not have BOD reduction effects. Actual costs in any situation will be a function of the reactor configuration imposed by the wastes received, and the progression of costs seem more likely to be higher or lower than to consist of the progressive doubling suggested by the rule of thumb.)

Unit costs are strongly affected by volume of water to be treated. In general, increase in component size is directly proportional to increase in flow volume; while increase in component cost is less than increase in component size. Depending on design and function, capacity increments have been determined to involve cost increments of 0.6 to 0.85. (This form of economy

of scale seems to hold through a treatment plant size of about 100 million gallons per day capacity, regardless of kind of treatment. Beyond 100 million gallons per day, diseconomies begin to assert themselves and the cost to size curve has been demonstrated to turn back on itself.)

The fact that unit costs decrease with the size of the plant and increase with the level of treatment effectiveness that is required confers an incremental marginal cost advantage on large pulp and paper mills that enjoy similar economies of scale with respect to productive capital and labor. It will cost about two to three times as much per ton of output for a 200 ton per day mill to treat its wastes as for a 2,000 ton per day mill, assuming equal efficiency in water use. (Figure 1 and Table 15)

There has been an enormous volume of research devoted to waste treatment costs over the last couple of decades. Crude average cost per gallon or per capita values utilized in the nineteen-fifties and earlier have been superseded by the regression techniques that have attempted to correlate dollar values with each of the many variables involved in waste treatment--flow, detention time, influent concentrations, decay rates--over a range of conditions. Unfortunately, the breadth of observation has not been sufficient to permit useful multiple correlation techniques to be employed. Unhappily, too, observations have tended to be made, and results expressed, in terms of completed, multiple component facilities. Further, the bulk of such research has been devoted to the case of treatment of sewage, a fairly homogenous waste treatable with a narrow range of processes. Industrial waste treatment costs have tended to be reviewed through case studies or excessively generalized models.

In 1970 and 1971, EPA developed an industrial waste treatment cost model that is intended to relate a series of specific variables--wastes characteristics of manufacturing processes, location, plant size, and intensity of water use--to twelve standard waste treatment procedures. The model itself is extraordinarily complex, in that it synthesizes a waste flow for all manufacturing plants inventoried by Dun and Bradstreet, and more than a little abstract, in that it operates in terms of average values weighted for location. While the model is believed to provide an accurate general assessment of national industrial waste treatment costs and can probably predict the response of those costs to changes in regulatory, operational, or technological conditions with acceptable precision, its reliability tails off exponentially with degree of disaggregation.

Components of the general model can be utilized, however, to estimate costs of waste treatment for specific plants with acceptable precision when information about their waste discharges is available.

FIGURE 1: Construction Costs of Separable Waste Treatment Modules Employed in Chemical Pulping

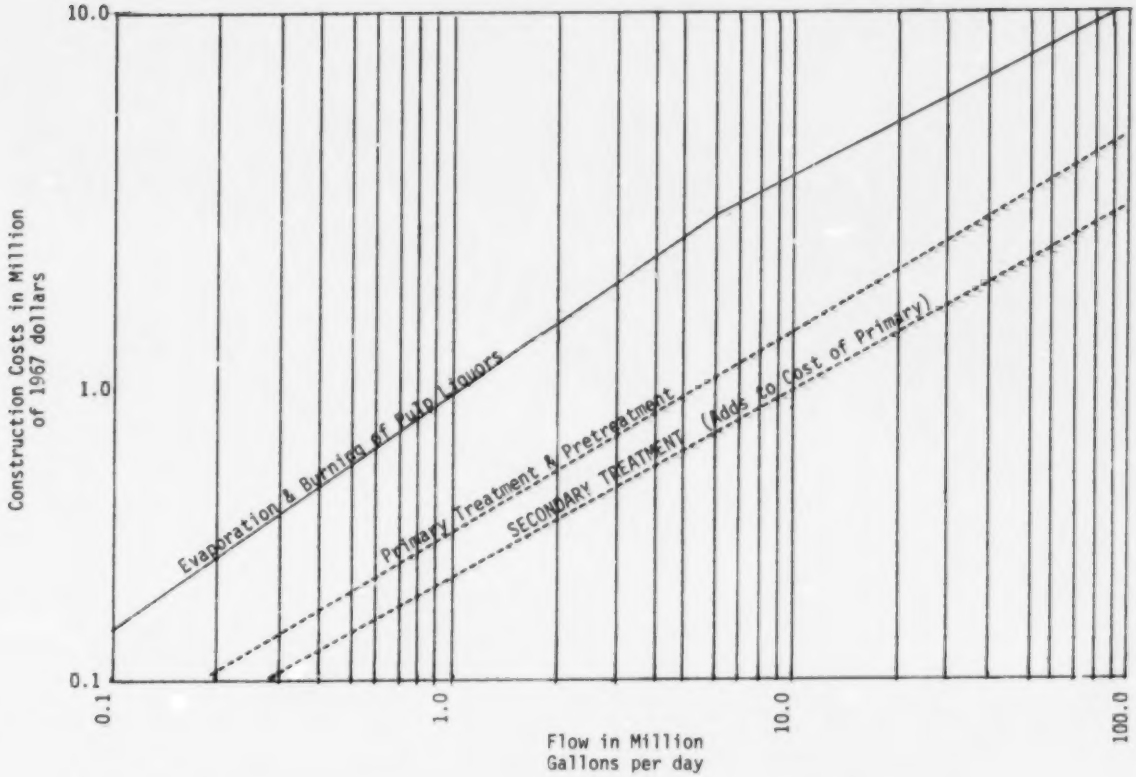


Table 15
Examples of Construction and Operating Costs
for Various Levels of Flow

Treatment Provided	Construction Cost in 1967 Dollars for Flows in Million gallons per day			
	0.10	1.0	10.0	100.0
Combustion	155,000	682,000	3,000,000	13,200,000
Sedimentation	80,000	282,000	1,011,000	3,616,000
Stabilization	27,000	110,000	523,000	2,300,000
Total	262,000	1,074,000	4,534,000	19,116,000
Dollars per gallon	2.62	1.07	0.45	0.19

Treatment Provided	Annual Operating Cost in 1967 Dollars for Flows in Million gallons per day			
	0.10	1.0	10.0	100.0
Combustion	31,300	133,000	564,700	2,397,400
Sedimentation	2,300	15,400	102,500	682,500
Stabilization	1,200	4,400	23,000	172,800
Total	34,800	152,800	690,200	3,252,700
Dollars per year per 1,000 gallons per day	0.99	0.44	0.20	0.09

The procedure is quite simple and straightforward, and while it cannot predict what a firm will spend for waste treatment, it does establish one set of costs that is compatible with solution of a waste treatment problem.

The essence of the method is (1) to define the appropriate set of treatment reactions for a waste of a given composition, (2) to determine the flow-based capacity necessary for each component (equalized daily flow multiplied by a strength factor), (3) to multiply the value obtained by cost to size factors determined by observation, and (4) to modify the products by additional factors that assess instiallation costs in excess of primary construction costs and regional price variations. (cf. Table 16 for the treatment process series and calculation factors.)

(N.B. While a number of the processes apply to sewage treatment as well as to industrial waste treatment, the cost to size equations reflect common industrial preferences with respect to handling of peak flows, and sizing to current loads. The dollar values obtained, then, are consistently below those for a municipal waste treatment series of similar description.)

That simplified waste treatment cost model has been applied to the effluent descriptions of Region X pulp and paper mills to assess three possible conditions:

1. The situation in which all mills utilize what has become an almost standardized treatment sequence for the industry: evaporation and burning of concentrated pulping wastes, mechanical clarification, and biological stabilization by use of aerated lagoons.

2. Addition of added treatment steps to the basic set where reported discharges either do not currently, or are unlikely--in terms of average efficiency--to achieve BOD and solids per ton values that meet preliminary guidelines for pulp mill effluents; the additional treatment measures include some combination of (a) incremental combustion capacity, (b) secondary sedimentation, or (c) incremental stabilization capacity for BOD removal.

3. Substitution of the conventional activated sludge treatment process, with separate sludge handling and return systems and secondary settling, for aerated lagoons in all cases where preliminary guidelines are not or may not be met by the standard treatment configuration.

The product of the calculations is three series of construction and annual cost values for Region X pulp and paper mills, providing estimates of both existing levels of capitalization and probable costs of total compliance with regulation under (1) the most likely technological assumptions, (2) the most likely modification of conventional technology for conditions that fail to meet stringent regulatory requirements, and (3) the most extreme technological adaptation to regulations that is possible, short of moving to kinds of waste treatment or internal controls that remain experimental.

All costs are presented in constant (August 1967) dollars. The most recent cost indices available suggest that construction costs were 40.5% higher by July 1972 and operating costs were about 32% higher by March 1972 than the quoted values. While interest and replacement rates are substantially unchanged from those used for the analysis, values should be adjusted in both cases to reflect inflation of the capital base upon which they operate.

Table 16
Cost to Flow Relationships of
Basic Waste Treatment Practices
(all costs in 1967 dollars)

Log (Cost) = A + Log (Flow) (B + Log (Flow))

Capital Cost Factors	A	B	C
1. Oil Separation	4.74702	0.92844	0.22100
2. Equalization	4.62325	0.74646	-0.22358
3. Coagulation-Sedimentation	5.52401	0.61843	0.00842
4. Neutralization	4.69097	0.98560	-0.52716
5. Flotation	4.59106	0.44964	-0.02748
6. Sedimentation	5.45089	0.55368	
7. Aeration	4.54407	0.23408	
8. Biological Stabilization	5.07555	0.64300	
9. Chlorination	4.17609	0.66317	
10. Evaporation	6.11227	1.00000	
11. Combustion	5.83373	0.64339	
12. Activated Sludge	5.73240	0.78430	

Operating Cost Factors (product in cents per 1000 gallons)			
1. Oil Separation	0.64345	-0.17671	
2. Equalization	-0.30103	-0.51016	0.06646
3. Coagulation-Sedimentation	0.86923	-0.11755	0.00586
4. Neutralization	0.24304	-0.10083	
5. Flotation	0.64345	-0.17671	
6. Sedimentation	0.64345	-0.17671	
7. Aeration	-0.30103	-0.51016	0.06646
8. Biological Stabilization	0.00934	-0.36057	0.07879
9. Chlorination	0.24304	-0.10083	
10. Evaporation	-0.71120	-0.24314	
11. Combustion	1.57978	-0.37205	
12. Activated Sludge	0.92940	-0.23730	

Regional Cost Factors

Construction cost multiplier:
- Pacific Northwest = 1.085
- Alaska = 1.377

Operating cost divisor:
- Washington = 0.840
- Oregon = 0.896
- Idaho = 0.993
- Alaska = 0.669

Installation Cost Factors (land acquisition, connection costs, production losses:)		
1. Oil Separation	0.25	X construction costs
2. Equalization	0.15	X " "
3. Coagulation-Sedimentation	0.25-0.35	X " "
4. Neutralization	0.15	X " "
5. Flotation	0.15-0.35	X " "
6. Sedimentation	0.35	X " "
7. Aeration	0.15	X " "
8. Biological Stabilization	0.25	X " "
9. Chlorination	0.15	X " "
10. Evaporation*	0.10*	X " "
11. Combustion	0.45	X " "
12. Activated Sludge	0.25-0.35	X " "

(*note: land costs basic in capital evaluation)

IV. COST OF WASTE TREATMENT TO REGION X PULP AND PAPER MILLS

Investments

Application of the waste discharge data available for Region X pulp and paper mills to the evaluation process described in the previous section of this report indicates that those mills have invested the equivalent of $96 million (1967 = 1.00) in capital facilities whose primary or only purpose is the treatment of liquid wastes. (cf. Table 17)

The values are not, of course, reflections of balance sheet values. They are approximations of the cost of installing facilities of the indicated descriptions, based on national average experience weighted for Region X conditions. Variations from actual expenditures may be substantial for any given plant, due to one or more of these influences:

1. Price level changes in construction have been significant over the period in which facilities have been installed. A clarifier constructed in 1972 would have cost almost twice as much as a similar unit installed in 1960. (For the purposes of this report, all dollar values are expressed in 1967 purchasing power equivalents.)

2. The evaluation assumes that all facilities were designed to achieve standard reduction efficiencies and were constructed to materials and reliability specifications as rigorous as those employed in municipal sewage treatment. In fact, plants may in some instances be underdesigned and construction may be of a different quality than that upon which the evaluation procedures are based. (N.B. Underdesign may be anticipated to reduce the effectiveness of treatment in all cases in which it occurs. That is not true of cost-cutting construction methods and materials, where the deviation from evaluation norms must be assumed to be neutral with respect to efficiency in the absence of specific information. The technical literature is full of imaginative, cost-cutting approaches to industrial waste treatment that equal or exceed the effectiveness of standardized methods.)

3. The evaluation is based on the quantity and strength of discharge into components of the waste treatment system. It does not, and cannot, account for processing

modifications that affect those variables ahead of the treatment system. Such modifications--or initial design features--absorb a greater or lesser proportion of the cost of treatment, but impose costs in themselves in most cases. Whether rigorous waste control engineering throughout a plan reduces the total cost of waste handling and treatment or not, its effect on net cost of treatment is invariably to reduce it. For this reason, investments and annual costs may be presumed to be significantly understated in the cases of some establishments that provide very effective waste reduction (e.g., Western Kraft and Weyerhaeuser, Springfield), just as they may be overstated in the cases of establishments with underdesigned and inadequately operated systems.

The bulk of the capital outlay made to date has been expended in the Willamette and Lower Columbia Basins (55 percent for 48 percent of regional capacity) and for primary treatment and pretreatment measures.

For those plants that have been forced to convert from calcium sulfite pulping to a recoverable chemical base as an operational precondition to treatment, investments for evaporation and burning of digester wastes have utilized the largest share of the capital that has been invested--and estimated $25 million compared to $17 million for primary and secondary treatment. Actual cash outlays may confidently be assumed to have been significantly greater than the indicated $25 million, in that the value represents only the cost of equipment for the evaporation and burning itself, with no recovery except of potential heat values. In practice, the establishments have in every case installed the additional equipment necessary for recovery of pulping chemicals, and have modified digesters as necessary for that kind of operation. The cost of additional air pollution control devices may also be attributed to the installation of the chemical recovery step. It is probably not at all unreasonable to assess the total capital commitment involved in the conversion from calcium sulfite pulping at very close to $50 million for the five Region X mills that have undertaken it. It should be noted, however, that investment in chemical recovery systems - whether motivated by waste control regulation or not - may be expected to <u>reduce</u> the cost of pulp production and to add to profits. While management might prefer to make alternative dispositions of capital funds in the absence of regulatory pressures, losses can be inferred only in a relative sense, so that the only economic cost associated with chemical recovery is probably the opportunity cost it represents.

Table 17

Current Replacement Value of
Installed Facilities

	Location	VALUE OF INSTALLED FACILITIES (1967 dollars) Evaporation	Sedimentation	Stabilization	TOTAL
Alaska Lumber & Pulp	Sitka	Pdtn. Comp.*	--	--	--
Ketchikan	Ketchikan	Pdtn. Comp.	--	--	--
	ALASKA		--	--	--
Boise Cascade	Steilacoom	N.A.	1,100,000	--	1,100,000
Crown Zellerbach	Port Angeles	N.A.	1,600,000	--	1,600,000
	Port Townsend	Pdtn. Comp.	--	--	--
Georgia Pacific	Bellingham	By-Pdt.Rcvy.	--	--	--
Rayonier	Port Angeles	--	--	--	--
St. Regis	Tacoma	Pdtn. Comp.	2,700,000	--	2,700,000
Scott	Anacortes	--	1,400,000	--	1,400,000
	Everett	--	4,000,000	--	4,000,000
Simpson Lee	Everett	Pdtn. Comp.	--	--	--
Weyerhaeuser	Everett	Pdtn. Comp.	--	--	--
	Everett	--	2,600,000	--	2,600,000
	PUGET SOUND		11,000,000	--	11,000,000
Rayonier	Hoquiam	Pdtn. Comp.	3,000,000	--	3,000,000
Weyerhaeuser	Cosmopolis	Pdtn. Comp.	2,700,000	1,400,000	4,100,000
	WASH. COAST		5,700,000	1,400,000	7,100,000
Georgia Pacific	Toledo	Pdtn. Comp.	--	--	--
International	Gardiner	Pdtn. Comp.	1,700,000	--	1,700,000
Menasha	North Bend	N.A.	660,000	--	660,000
	OREGON COAST		2,400,000	--	2,400,000
Boise Cascade	St. Helens	Pdtn. Comp.	2,800,000	1,500,000	4,300,000
Crown Zellerbach	Wauna	Pdtn. Comp.	3,700,000	--	3,700,000
	Camas	16,000,000	5,000,000	--	21,000,000
Longview Fibre	Longview	Pdtn. Comp.	4,000,000	--	4,000,000
Weyerhaeuser	Longview	Pdtn. Comp.	5,200,000	--	5,200,000
	LOWER COLUMBIA	16,000,000	21,000,000	1,500,000	38,000,000
American Can	Halsey	Pdtn. Comp.	1,700,000	860,000	2,600,000
Boise Cascade	Salem	2,900,000	2,100,000	1,100,000	6,100,000
Crown Zellerbach	Lebanon	1,400,000	1,000,000	470,000	2,900,000
	West Linn	N.A.	2,300,000	1,200,000	3,500,000
Publishers	Newberg	2,100,000	1,500,000	730,000	4,600,000
	Oregon City	2,100,000	2,800,000	1,500,000	6,400,000
Western Kraft	Albany	Pdtn. Comp.	1,100,000	520,000	1,600,000
Weyerhaeuser	Springfield	Pdtn. Comp.	2,000,000	1,000,000	3,000,000
	WILLAMETTE	9,700,000	15,000,000	7,400,000	31,000,000
Boise Cascade	Wallula	Pdtn. Comp.	1,200,000	--	1,200,000
Inland Empire	Millwood	N.A.	770,000	--	770,000
Potlatch	Lewiston	Pdtn. Comp.	2,800,000	--	2,800,000
	UPPER COLUMBIA		4,800,000	--	4,800,000
	REGION X	25,000,000	62,000,000	10,000,000	96,000,000

The value of facilities installed to date represents something more than half of the total required to provide all plants with the sequence of treatment measures generally thought by regulatory authority to be necessary for pulp and paper mills. Another $82 million of investment would be required to bring all plants up to the facility availability standard utilized for evaluation purposes--generally expressed as 'the equivalent of secondary treatment of municipal wastes.' (cf. Table 18) More than half of the unmet requirement--$43 million--is associated with the Puget Sound component of the industry. (Although closure of two mills at Everett will eliminate about $6 million of that requirement.)

The investment that remains to be made is associated largely with installation of secondary easte treatment procedures. No evaporation and burning equipment deficiencies exist outside of Puget Sound. (At least in a gross sense: substandard efficiency is indicated in several cases--particularly for sulfite recovery systems.) Only $7 million worth of investment in primary waste treatment is indicated for mills outside of Puget Sound and Alaska--and in two of the three cases of deficiency, primary treatment has been installed, but reported solids concentrations in the effluent are so high as to indicate the need for added capacity.

As with existing treatment works, investment requirements are dominated by evaporation and burning in those mills that do not currently practice chemical recovery. An estimated $18 million of the toal $28 million treatment investment required by five such mills represents the cost of the combustion stage, and it is safe to assume that the $18 million represents little more than half of the investment that will be expended to meet the waste treatment requirement in a manner that is operationally profitable and that complies with air pollution control requirements.

Annual Charges

Investments are not costs. It is inappropriate, both technically and realistically, to speak of the $180 million worth of waste treatment works required for Region X's pulp and paper industry as costs to the firms that constitute the industry. Rather, that investment constitutes a transfer of assets from some other form--cash, inventory reduction, claims on future earnings--into other assets, the specialized items of fixed capital that are required to continue to operate under existing and contemplated environmental regulations.

Costs are incurred through the production and exchange processes. They must be added to the price of the product (or otherwise transferred from consumers, owners, or other social elements) if the establishment is to continue to operate. As calculated and presented here, the costs of waste treatment are assumed to be incremental costs of production that include:

1. Payments for labor, for chemicals, for electricity, for transportation (sludge disposal), and for routine maintenance that are imposed by the operation of waste treatment facilities;

2. Replacement or extraction of capital invested in treatment facilities at the rate of 5 percent a year;

3. Opportunity costs, or capital service costs, of waste treatment works calculated at 7.7 percent a year, the prevailing rate for long-term industrial bonds.

(N.B. Neither operating and maintenance nor capital replacement charges for chemical recovery facilities have been added into annual costs for those establishments that have converted, or are expected to convert, to chemical recovery systems as a consequence of water pollution abatement requirements. Such charges are considered to be production costs, and their net effect on the total costs and waste treatment costs of the establishment are thought to be negative in most cases. Interest charges for such facilities are, however, included in the annual cost values presented here, on the basis that the failure of management to install such facilities in the absence of regulatory pressure is a clear indication that higher returns on the necessary capital were elsewhere available. Under those circumstances, opportunity costs--assumed to be equal to interest charges--should be charged against waste treatment, even though charging either the gross costs or net savings associated with such facilities against waste treatment would distort those costs, by overstatement or understatement, respectively. In particular, the relative cost burden between sulfite and sulfate production processes would be seriously distorted, in that chemical recovery is invariably associated with production costs in the sulfate process.)

Given those definitions of costs, Region X pulp mills are currently paying more than $18 million (1967 = 100) a year to treat their wastes. (cf. Table 19)

On the assumption that 350 days is a normal operating year and that the mean operating rate is 95 percent of rated capacity over the operative period, waste treatment currently adds $2.80 a ton to the cost of producing wood pulp in Region X.

The degree of waste treatment performed appears to have little influence on unit costs of waste treatment. Those mills that provide no treatment (including chemical pulping plants that practice chemical recovery but no specific waste treatment operations) incur no waste treatment costs. But sulfite mills that only provide primary treatment would seem to have higher charges per ton of

output on average than do mills that accomplish significantly greater waste reductions:

	Waste Treatment Cost Per Ton
No Waste Treatment	$ 0
Primary Treatment only, groundwood	3.20
Primary Treatment only, chemical pulping	4.20
Burning of Digester Wastes and Primary Treatment	3.00
Burning of Digester Wastes, Primary and Secondary Treatment	3.85

The data should not be interpreted to mean that waste treatment costs do not rise with degree of treatment accomplished. Rather, they indicate that other variables--plant size, product and process composition, internal controls of water and of waste products--have an even greater influence on waste treatment costs than does the degree of treatment.

Given that fact, it is surprising to find that the mills that have installed waste treatment are not in all cases the ones for whom it would be cheapest. The model indicates that if all Region X mills were to install and operate the full range of treatment processes currently required, they would incur another $13 million a year in charges. (cf. Table 20) Thus the industry has supplied 55 percent of the necessary investment, but already incurs 58 percent of the ultimate annual costs. At least two explanations come readily to mind. On the one hand, there are intensive as well as extensive economies of scale in the waste treatment process, such that operating costs do not increase proportionally with capital investment--at least through the conventional pretreatment--primary treatment, secondary treatment sequence. Another possible explanation is to be found in regulatory behavior. Some relatively expensive treatment decisions have been implemented in Grays Harbor and the Willamette Valley, where the environmental payoff could be expected to be high; while Puget Sound and the Oregon Coast, where less costly opportunities for treatment are available, seem to have been given less emphasis.

Whatever the reason may be, the costs to the industry of servicing the additional waste treatment investment that will be required to reach secondary treatment capabilities will not be proportional to increase in investment. The ratio of annual costs to investment for facilities currently in place is about .19 to 1.0; for incremental investment it is about .16 to 1.0, or 15 percent lower.

Table 18
Incremental Investment
Required to Achieve
Treatment Norms

Firm	Location	Value of Required Facilities (1967 dollars) Evaporation	Sedimentation	Stabilization	Total
Alaska Lbr&Pulp	Sitka	---	4,200,000	2,300,000	6,500,000
Ketchikan Pulp	Ketchikan	---	4,700,000	2,600,000	7,300,000
	ALASKA		8,000,000	4,900,000	14,000,000
Boise Cascade	Steillacoom	---	---	510,000	510,000
Crown Zellerbach	Port Angeles	---	---	800,000	800,000
	Port Townsend	---	1,900,000	1,000,000	1,900,000
Georgia Pacific	Bellingham	4,100,000	2,900,000	1,600,000	8,600,000
Rayonier	Port Angeles	3,900,000	2,600,000	1,400,000	7,900,000
St. Regis	Tacoma	---	---	1,500,000	1,500,000
Scott	Anacortes	1,900,000	---	580,000	2,500,000
	Everett	5,500,000	---	2,000,000	7,500,000
Simpson Lee	Everett	---	1,600,000	700,000	2,300,000
Weyerhaueser	Everett	---	2,800,000	1,500,000	4,300,000
	Everett	2,900,000	---	1,000,000	3,900,000
	PUGET SOUND	18,000,000	12,000,000	13,000,000	43,000,000
Rayonier	Hoquiam	---	---	2,300,000	2,300,000
Weyerhaueser	Cosmopolis	---	---	---	---
	WASH. COAST	---	---	2,300,000	2,300,000
Georgia Pacific	Toledo	---	1,700,000	840,000	2,600,000
International	Gardiner	---	---	880,000	880,000
Menasha	North Bend	---	300,000	280,000	580,000
	ORE. COAST	---	2,000,000	2,000,000	4,000,000
Boise Cascade	St. Helens	---	---	---	---
Crown Zellerbach	Wauna	---	---	2,100,000	2,100,000
	Camas	---	---	3,100,000	3,100,000
Longview Fibre	Longview	---	---	2,300,000	2,300,000
Weyerhaueser	Longview	---	4,900,000	3,100,000	8,000,000
	LOWER COLUMBIA	---	4,900,000	11,000,000	16,000,000
American Can	Halsey	---	---	---	---
Boise Cascade	Salem	---	---	---	---
Crown Zellerbach	Lebanon	---	---	---	---
	West Linn	---	---	---	---
	Newberg	---	---	---	---
	Oregon City	---	---	---	---
Western Kraft	Albany	---	---	---	---
Weyerhaueser	Springfield	---	---	---	---
	WILLAMETTE	---	---	---	---
Boise Cascade	Wallula	---	---	560,000	560,000
Inland Empire	Millwood	---	---	330,000	330,000
Potlatch	Lewiston	---	---	1,500,000	1,500,000
	UPPER COLUMBIA	---	---	2,400,000	2,400,000
	REGION X	18,000,000	28,000,000	36,000,000	77,000,000

Table 19
Current Level of Annual Waste
Treatment Costs

Firm	Location	Annual Cost of Waste Treatment (1967 dollars) Operations	Replacement	Interest	TOTAL	Per Ton of Output
Alaska Lumber & Pulp	Sitka	--	--	--	--	--
Ketchikan Pulp	Ketchikan	--	--	--	--	--
	ALASKA	--	--	--	--	--
Boise Cascade	Steilacoom	80,100	41,300	84,700	206,000	2.80
Crown Zellerbach	Port Angeles	140,800	60,400	123,200	324,400	3.70
	Port Townsend	--	--	--	--	--
Georgia Pacific	Bellingham	--	--	--	--	--
Rayonier	Port Angeles	--	--	--	--	--
St. Regis	Tacoma	304,800	101,500	207,900	614,200	2.10
Scott	Anacortes	112,900	52,000	107,800	272,700	5.90
	Everett	526,900	146,600	308,000	981,500	3.50
Simpson Lee	Everett	--	--	--	--	--
Weyerhaeuser	Everett	--	--	--	--	--
	Everett	282,400	96,400	200,200	579,000	5.60
	PUGET SOUND	1,447,900	498,200	1,031,800	2,977,900	1.90
Rayonier	Hoquiam	356,000	112,600	231,000	699,600	4.20
Weyerhaeuser	Cosmopolis	363,800	156,400	315,700	835,900	6.30
	WASH. COAST	719,800	269,000	546,700	1,535,500	5.10
Georgia Pacific	Toledo	--	--	--	--	--
International	Gardiner	150,900	66,100	130,900	347,900	1.70
Menasha	North Bend	34,000	24,300	50,800	109,100	2.20
	ORE. COAST	184,900	90,400	181,700	457,000	0.80
Boise Cascade	St. Helens	367,900	164,900	331,100	863,900	3.20
Crown Zellerbach	Wauna	453,700	138,500	284,900	877,100	2.60
	Camas	839,200	200,500	1,617,000	2,656,700	7.00
Longview Fibre	Longview	543,800	149,700	308,000	1,001,500	1.60
Weyerhaeuser	Longview	802,400	194,500	400,400	1,397,300	5.00
	L. COLUMBIA	3,007,000	848,100	3,789,500	7,644,600	4.10
American Can	Halsey	178,100	98,700	200,200	477,000	4.30
Boise Cascade	Salem	239,600	121,800	469,700	831,100	10.00
Crown Zellerbach	Lebanon	83,500	57,400	223,300	264,200	11.10
	West Linn	269,100	132,300	269,500	670,900	11.20*
Publishers	Newberg	144,700	85,100	354,200	584,000	3.50
	Oregon City	355,500	161,000	492,800	1,009,300	5.10
Western Kraft	Albany	94,900	62,900	123,200	281,000	1.10
Weyerhaeuser	Springfield	216,700	113,500	231,000	561,200	1.50
	WILLAMETTE	1,582,100	832,700	2,363,900	4,778,700	3.70
Boise Cascade	Wallula	91,000	45,000	92,400	228,400	1.00
Inland Empire	Millwood	46,500	28,700	34,700	109,900	5.00
Potlatch	Lewiston	270,400	104,800	215,600	590,800	1.80
	UPPER COLUMBIA	407,900	178,500	342,700	929,100	1.60
	REGION X	7,349,600	2,716,900	8,256,300	18,322,800	2.80

*Based on pulping capacity. A substantial portion of costs is attributable to paper production.

Table 20

Incremental Annual Cost of
Treatment Upgraded to Industry Norm

FIRM	Location	Incremental Annual Cost (1967 Dollars) Operations	Replacement	Interest	Total	Per Ton of Output
Alaska Lbr.& Pulp	Sitka	633,600	249,700	500,500	1,383,800	5.70
Ketchikan Pulp	Ketchikan	746,500	433,000	562,100	1,741,600	8.30
	ALASKA	1,380,100	682,700	1,062,600	3,125,400	6.90
Boise Cascade	Steilacoom	18,400	20,400	39,300	78,100	1.10
Crown Zellerbach	Port Angeles	31,500	31,700	61,600	124,800	1.40
	Port Townsend	223,200	110,700	223,300	557,200	4.10
Georgia Pacific	Bellingham	416,700	172,000	662,600	1,251,300	6.60
Rayonier	Port Angeles	351,300	152,600	608,300	1,112,200	6.90
St. Regis	Tacoma	69,300	58,000	115,500	242,800	0.80
Scott	Anacortes	21,400	23,200	192,500	237,100	5.10
	Everett	105,000	78,300	577,500	760,800	2.70
Simpson Lee	Everett	165,600	86,900	177,100	429,600	7.50
Weyerhaeuser	Everett	381,300	161,600	331,100	874,000	6.40
	Everett	44,300	41,400	292,500	378,200	3.70
	PUGET SOUND	1,828,000	936,800	3,281,300	6,046,000	3.90
Rayonier	Hoquiam	135,700	93,800	177,100	406,600	2.40
Weyerhaeuser	Cosmopolis	--	--	--	--	--
	WASH. COAST	135,700	93,800	177,100	406,600	1.40
Georgia Pacific	Toledo	173,700	97,000	200,200	470,900	1.40
International	Gardiner	33,700	35,200	67,800	136,700	0.70
Menasha	North Bend	21,200	23,500	44,700	89,400	1.80
	ORE. COAST	228,600	155,700	312,700	697,000	1.20
Boise Cascade	St. Helens	--	--	--	--	--
Crown Zellerbach	Wauna	107,200	83,200	161,700	352,100	1.10
	Camas	202,500	123,400	238,700	564,600	1.50
Longview Fibre	Longview	130,200	91,100	177,100	398,400	0.60
Weyerhaeuser	Longview	202,700	318,100	616,000	1,136,800	4.00
	LOWER COLUMBIA	642,600	615,800	1,193,500	2,451,900	1.30
American Can	Halsey	--	--	--	--	--
Boise Cascade	Salem	--	--	--	--	--
Crown Zellerbach	Lebanon	--	--	--	--	--
	West Linn	--	--	--	--	--
Publishers	Newberg	--	--	--	--	--
	Oregon City	--	--	--	--	--
Western Kraft	Albany	--	--	--	--	--
Weyerhaeuser	Springfield	--	--	--	--	--
	WILLAMETTE	--	--	--	--	--
Boise Cascade	Wallula	20,700	22,600	30,800	74,100	0.30
Inland Empire	Millwood	11,300	13,400	25,400	50,100	2.30
Potlatch	Lewiston	61,600	60,200	115,500	237,300	0.70
	UPPER COLUMBIA	93,600	96,200	171,700	361,500	0.60
	REGION X	4,308,600	2,581,000	6,198,900	13,088,500	2.00

TABLE 21

Estimated Increase in Production Costs
Attributable to Waste Treatment

Region	W.T. Costs Per Ton of Output (1967 Dollars)			Percent Expected Increase
	Current	Indicated Increment	Total	
Alaska	0	6.90	6.90	∞
Puget Sound	1.90	3.90	5.80	205%
Washington Coast	5.10	1.40	6.50	27%
Oregon Coast	0.80	1.20	2.00	150%
Lower Columbia	4.10	1.30	5.40	32%
Willamette	3.70	0	3.70	0
Upper Columbia	1.60	0.60	2.20	38%
Region X	2.80	2.00	4.80	71%

Impact on Firms

There are presently eighteen firms active in pulp and paper production in Region X. Three of them--Weyerhaeuser, Crown Zellerbach, and Boise Cascade--dominate the industry, operating fifteen of the thirty-four plants and accounting for more than 40 percent of total capacity. Among them, they have invested more than $60 million in waste treatment, and bear more than $10 million a year of waste treatment costs.

Such aggregate figures have little meaning, however. Tiny Inland Empire Paper Company appears to have invested more dollars per ton of production capacity in waste treatment works than any of the big three--more than twice as much as giant Weyerhaeuser--and its values added by waste treatment are, and will probably continue to be, significantly larger than those of the major firms.

The point is not that Inland Empire is more virtuous or deals with harsher regulatory treatment than bigger firms, it is that gross values have little meaning with respect to the competitive standing of individual firms. Such values must be related to some objective standard of comparison to properly gage their significance.

When waste treatment outlays are expressed in terms of capacity or output, the variability in inter-firm impact of Region X operations is found to be great. (cf. Table 22) Total investment requirements vary from $2,100 per ton of capacity for Western Kraft to almost $16,000 per ton for Scott Paper Company; incremental capital requirements range from zero for three firms to more than $10,000 per ton for four others. Current additions to operating costs imposed by waste treatment range from nothing to $5 a ton. If all plants meet the secondary waste treatment requirement, treatment costs per ton of output will vary from $1.10 for Western Kraft to over $8.00 for Ketchikan Pulp.

Location obviously affects the costs that can be anticipated by the two Alaskan producers, but other elements also influence the expectations of firms.

Size composition of establishments clearly plays a significant role in determining inter-firm cost distribution. While the association is by no means direct, there is a definite relationship between average size of plan and waste treatment costs absorbed. (cf. Figure 2)

The inverse correlation of unit cost with size of plant could have been predicted from a knowledge of the homogenity of waste treatment procedures and of the general principle of economy of scale. (Refer back to Figure 1.) The correlation should not be over-emphasized, however. Though the larger plant has a distinctly advantageous cost structure in comparison with the smaller plant, those advantages are to some extent associated not with size per se, but with size as an expression of product specialization. And, as has been noted in Section 1 of this report, products and processes have a major influence on the volume and strength of waste produced per ton of product output.

Volume and strength of waste quite obviously affect the cost of waste treatment, even though the same waste treatment methods apply to most of the product/process groupings. Those relationships become quite clear when product class aggregated unit waste treatment costs are calculated and arrayed. It would appear that values added by waste treatment are distinctly greater than those that trace directly to plan size; although size of plant may be a significant determinant of cost within a product or process category. (cf. Table 23)

The significance of these factors to the financial conditions and competitive standing of firms would appear to be obvious. It is probably safe to assume that waste treatment costs will ultimately be imbedded in product prices. Given that hypothesis, several postulates emerge.

1. If all pulp and paper prices reflect waste treatment costs, firms may be expected to bargain aggressively for subsidies that permit some or all of the price component to be diverted to profits. Obviously, the largest possible subsidy is evasion of regulation; but both delay and substandard performance are profitable modes of behavior--and their degree of profitability will increase directly with the increase in overal costs of waste treatment and the conversion of those costs into product prices.

2. Average cost per firm is a poor guide to the relative impact of pollution control regulation on profits and competitive standing. Because costs vary with process and product groupings, price adjustments may be anticipated to take place within specific product lines. Where a product may be developed through application of alternative processes and one of those processes has a distinctly lower waste treatment cost, the visbility of mills employing other processes will be reduced, all other things being equal.

3. Because of the economies of scale inherent in waste teatment, application of across-the-board treatment requirements will accelerate the trend to larger mills. The consequences will include larger point source residual discharges, more extensive forest exploitation, greater expenditures of energy and materials displacement in the production of pulp and paper. These unfortunate environmental consequences of direct environmental regulation (not to mention their social side effects) must be recognized by both mill management and regulatory authorities; and measures to counter them must be developed if a positive balance is to be achieved from environmental outlays.

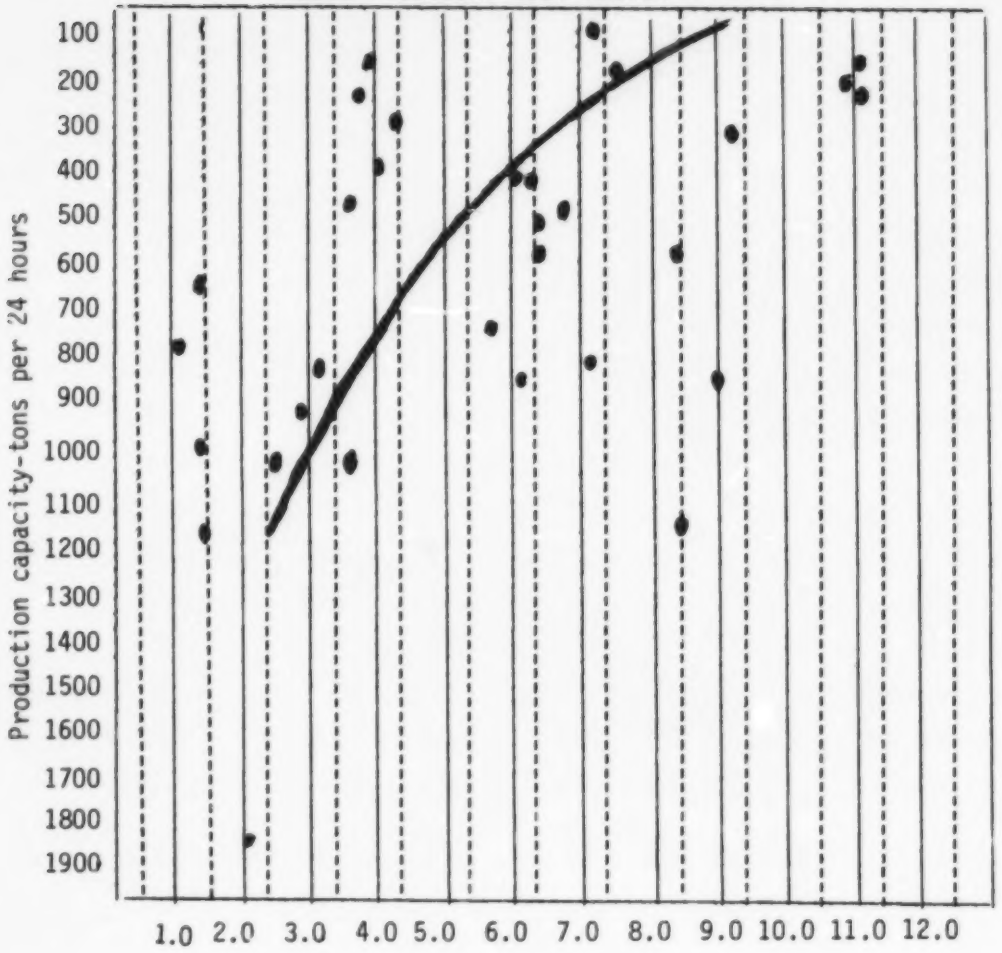
4. Within any product category the comparison of unit waste treatment costs for a specific mill with the industry average for mills of that type could provide a useful guide to expectation for continued operation. Mills distinguished by higher than average waste treatment costs may be assumed to be vulnerable to closure in the absence of substantial recapitalization measures. That does not imply that waste treatment costs are, in themselves, critical to the operations or profitability of any mill. It must be recognized, however, that relative waste treatment costs recapitulate, and are a consequence of, a whole series of influences--age, size, market growth, capitalization--that determine the efficiency of a given plant. Waste treatment costs, then, are an incremental effect in a cumulative process that determines which plants will survive.

Table 22
Inter-Firm Impact of
Meeting Waste Treatment Norms

FIRM	Plants Capacity	Required Investment	Existing Investment	Required Annual Cost	Existing Annual Cost	TOTAL Investment	Annual Cost
		OUTLAY PER TON IN 1967 DOLLARS					
Alaska Lbr & Pulp	1 / 725 T/D	9,000	0	5.70	0	9,000	5.70
American Can	1 / 330 T/D	7,900	7,900	4.30	4.30	0	0
Boise Cascade	4 / 1936 T/D	7,100	6,600	3.50	3.30	500	0.20
Crown Zellerbach	6 / 3018 T/D	13,400	10,000	6.30	4.80	2,800	1.50
Georgia Pacific	2 / 1572 T/D	7,100	0	3.40	0	7,100	3.40
Inland Empire	1 / 66 T/D	16,000	11,700	7.30	5.00	5,000	2.30
International	1 / 600 T/D	4,300	2,800	2.40	1.70	1,500	0.70
Ketchikan Pulp	1 / 630 T/D	11,600	0	8.30	0	11,600	8.30
Longview Fibre	1 / 1850 T/D	3,400	2,200	2.20	1.60	1,200	0.60
Menasha	1 / 150 T/D	8,000	4,400	4.00	2.20	3,600	1.80
Potlatch	1 / 1000 T/D	4,300	2,800	2.50	1.80	1,500	0.70
Publishers	1 / 1094 T/D	10,000	10,000	4.60	4.60	0	0
Rayonier	2 / 390 T/D	13,300	3,000	6.70	2.10	10,300	4.60
St. Regis	1 / 887 T/D	4,700	3,000	2.90	2.10	1,700	0.80
Scott	2 / 976 T/D	15,800	5,500	6.80	3.90	10,300	2.90
Simpson Lee	1 / 173 T/D	13,200	0	7.50	0	13,300	7.50
Western Kraft	1 / 770 T/D	2,100	2,100	1.10	1.10	0	0
Weyerhaeuser	5 / 3121 T/D	10,000	4,800	5.50	3.30	5,200	2.20
Less Everett Sulfite	4 / 2811 T/D	8,800	4,400	5.10	3.00	4,400	1.90
REGION X	34 / 19,965	8,900	4,800	4.80	2.80	4,100	2.00
Less Two Everett Mills	32 / 19,485	8,700	4,800	4.60	2.80	3,900	1.80

*Everett counted as sunken capital loss and not reflected.

FIGURE 2
Generalized Relationship
of Mill Size to
Waste Treatment Cost REGION X Mills



Waste Treatment Costs per ton output (1967 dollars)

Curve = Average cost per ton across valid size range

Points = Cost per ton of specific mills

Table 23
Values Added By
Waste Treatment by Product
and Process Categories

ESTABLISHMENT CATEGORY	Mean 24 Hour CAPACITY	Cost per Ton MEAN	Cost per Ton RANGE	Number of Mills
Fine paper, tissue, dissolve pulp	485T	$8.00	$6.20-11.20	10
Sulfite pulps	477	7.70	5.70-11.10	13
Groundwood-NSSC pulps	176	5.10	3.90- 7.30	5
Newsprint	222	4.10	3.50- 5.10	4
Packaging	788	2.90	1.10- 6.40	14
Sulfate pulps	836	2.80	1.10- 6.40	13
All Mills	587	4.80	1.10-11.20	34

*Some multi-product and/or multi-process mills are not included in the tabulation

Appendix

The artificial nature of the treatment cost values that form the basis of this report must be acknowledged. Use of models inevitably causes doubts, and in situations that have the great potential for variation that waste treatment presents, those doubts may be large. It may be useful, then, to compare the calculated construction costs of specific facilities with the reported costs of the same facilities, where they have appeared in industry publications:

	Investment		
Establishment	Reported	Calculated	Nature of Facility
Boise Cascade, Steilacoom	$ 800,000	$ 1,100,000	primary treatment
Salem	6,400,000	6,100,000	total treatment system
Crown Zellerbach	2,500,000	1,900,000	primary treatment
Camas	15,500,000	16,000,000	recovery system
West Linn	2,500,000	3,500,000	secondary treatment
Publishers Paper, Oregon City	3,600,000	4,300,000	secondary treatment
Newberg	6,300,000	2,300,000	recovery system
Rayonier, Hoquiam	2,700,000	3,000,000	primary treatment
St. Regis, Tacoma	1,900,000	2,700,000	primary treatment
Eight treatment facilities	$42,200,000	$40,900,000	

Although the total reported value is somewhat higher than the calculated value, modelled costs are higher in six of nine cases. Two of the three cases in which reported costs exceed calculated costs involve the installation of chemical recovery systems, where modelled values extend only to those engineering features essential to liquid waste treatment. There would seem, then, to be a distinct tendency for the modelling procedure to assess costs at a level somewhat in excess of those encountered in reality.

Table 24
Comparison of Reported or Modelled "Secondary Equivalent"
with Proposed "Best Practicable Treatment" Guidelines

FIRM	LOCATION	CURRENT TREATMENT			BOD/TON			SOLIDS/TON			VIOLATION	
		E&B	P	S	BPT	RPTD	MDLD	BPT	RPTD	MDLD	BOD	Solids
Alaska Lumber & Pulp	Sitka, AK	X			60	378	92	80	141	54	X	
American Can	Halsey, OR	X	X	X	9	4		10	5			
Boise Cascade	Steilacoom, WA	NA	X		4.5	44	15	6	51	36	X	X
	St. Helens, OR	X	X	X	11	31		12	28		X	X
	Salem, OR	X	X	X	35	32		40	15			
	Wallula, WA	X	X		8	34	12	12	25	18	X	X
Crown Zellerbach	Port Angeles, WA	NA	X		4.5	44	15	6	83	58	X	X
	Port Townsend, WA	X			9	39	10	10	17	7		
	Wauna, OR	X	X		9	71	25	10	21	15	X	X
	Camas, WA	X	X		<35	150	53	<40	40	28	X	
	Lebanon, OR	X	X	X	35	53		40	30		X	
	West Linn, OR	X	X	X	20	39		23	183		X	X
Georgia Pacific	Bellingham, WA	?			35	230	56	40	75	12	X	
	Toledo, OR	X			9	30	7	10	21	8		
Inland Empire	Spokane, WA	NA	X		10	84	29	12	13	9	X	
International Paper	Gardiner, OR	X	X		9	43	15	10	34	24	X	X
Ketchikan Pulp	Ketchikan, AK	X			60	178	43	80	85	14		
Longview Fibre	Longview, WA	X	X		11	58	20	15	35	25	X	X
Menasha	North Bend, OR	NA	X		14	90	32	25	62	43	X	X
Potlatch	Lewiston, ID	X	X		11	78	27	12	38	27	X	X
Publisher's Paper	Newberg, OR	X	X	X	20	12		23	16			
	Oregon City, OR	X	X	X	26	14		29	14			
ITT Rayonier	Port Angeles, WA				60	1105	87	80	80	19	X	
	Hoquiam, WA	X	X		60	629	215	80	58	41	X	
St. Regis	Tacoma, WA	X	X		9	69	24	10	15	10	X	
Scott Paper	Anacortes, WA		X		35	814	101	40	56	28	X	
	Everett, WA		X		>35	689	57	>40	33	12	X	
Western Kraft	Albany, OR	X	X	X	9	3		10	7			
Weyerhaeuser	Everett, WA	X			9	57	14	10	49	19	X	X
	Longview, WA	X	X		23	214	75	25	600	420	X	X
	Cosmopolis, WA	X	X	X	60	260		80	22		X	
	Springfield, OR	X	X	X	9	2		10	6			

E&B = Evaporation & burning of concentrated pulping liquors
P = Primary
S = Secondary

BPT = Best Practicable Treatment
RPTD - Reported as Current Discharge
MDLD = Modelled Discharge, Given Incremental Treatment as Necessary to the Secondary Level

V. IMPACT OF EFFLUENT STANDARDS

Both administrative practice and legislative enactments in the environmental management area have demonstrated an increasing tendency to ignore direct consideration of the environmental effects of economic activities and to concentrate instead on technological features that relate to kinds of waste products and the nature of their disposal. (This analysis is a reflection of that tendency, in that it relates costs to specific water processing procedures rather than to modifications required to protect the quality of specific waste receiving waters.)

The tendency is probably strongest in water pollution control, where 1972 amendments to existing Federal legislation shifted the thrust of regulatory programs away from achievement of stipulated water quality criteria and toward the achievement of a series of broadly stated technological standards for direct waste discharges. The language of the legislation is less than precise as it relates to industrial waste discharges, requiring that they receive "best practicable waste treatment" by July 1, 1977, and "best available waste treatment" thereafter. The responsibility for defining the objective correlatives of "best practicable" and "best available" waste treatment has been left to the Administrator of EPA.

Given the variety of products and processes involved, not to mention the enormous possible variation in the efficiency of processes and their possible combinations, that task of definition is probably the most significant and difficult duty ever imposed in the environmental management field in the United States. The consequences of those definitions will be great--not only with respect to water quality, but also to quality of soils and air which will become the necessary repositories for materials extracted from wastewater, and with respect to product prices, competitive structure, and international trade prospects of American firms.

In practice, EPA has--understandably enough--avoided questions of environmental and economic side-effects and concentrated on providing definitions that relate to production and waste treatment technologies, linking them in

terms that reflect waste constituent parameters known to be significant in particular industry categories, maximum employment of waste treatment, and output levels. Effluent guidelines developed to date take the form of allowable waste to product ratios for categories of products for which the effect of a high degree of waste treatment has either been demonstrated or can be calculated. In the case of pulp and paper, the effluent guidelines embody the assumption of the availability of the set of treatment measures previously embodied in this analysis, together with a high degree of wastewater control within the production process.

They prove to be very stringent standards. Ten of the 34 Region X pulp mills currently (August 1972) provide the full sequence of waste treatment measures upon which the effluent guidelines ("A" schedule "best practicable treatment") are based. But when the reported discharges of those mills are compared with the effluent limits that appear on the basis of the product-process mix to apply to them, six mills meet the standard, two mills appear to violate allowable limits for BOD, and two mills appear to violate allowable limits for both BOD and Solids. It seems clear that the availability of the technological equivalent of best practicable treatment is not enough in itself to guarantee compliance with effluent limits.

Application of the process/discharge relationships presented in Table 14 to the 22 mills that do not currently provide the process sequence that is considered to constitute best practicable treatment (two mills are closing) suggests that 19 of them may not meet appropriate effluent guidelines after the standard waste treatment sequence is installed. Assuming that situation, the $180 million investment postulated for the regional industry will not be sufficient to assure its compliance with existing interpretations of Federal law. **(c.f.** Table 24)

It must be noted that the analytical values presented in this section are far less reliable than those in preceding sections. They must be considered to be provisional--almost illustrative--for a number of reasons, notably:

1. The ultimate effects of waste treatment are calculated rather than reported values in most cases, and they include the more conservative assessment--i.e., mean rather than median effectiveness reported for plants currently reporting waste treatment--of treatment effects.

2. There is only the most general relationship between the incremental treatment measures evaluated in this section and their intended effects. The sequence of additional facilities illustrates the general shape of the cost curve that may be anticipated as increasingly greater waste reductions are required; it does not necessarily present the optimum--or even feasible--response to the indicated circumstances.

3. Most significantly, there are compelling indications that waste reductions sufficient to meet effluent limitations must be achieved in good part through process management and stringent reduction of water use. It is entirely possible that no incremental waste treatment measures will prove to be adequate to meet the preliminary effluent guidelines in the absence of such process water controls, and equally possible that such controls may obviate the necessity to install additional waste treatment. *

* Ralph Scott's comments on the matter present the issue cogently:

The report contains some excellent information relative to satisfaction of present suggested guidelines by Pacific Northwest mills. Largely it is assumed that added treatment, above secondary, will be needed to meet standards. This is not necessarily so. Standards were developed, and will be subsequently redeveloped, employing averages of best operated mills. Treatment is SOP through secondary and we can forecast that result. The main issue is raw waste loading per ton and mill variation therein. Recovery overload has been responsible for much of the higher per ton waste values. Air pollution control will be a significant aid in correcting this situation. In chemical pulping about one-third of the load per ton derives each from recovery, condensate load and bleaching. In unbleached production, naturally this load is less. In any case, advances in reduced loading must revolve around control or improvement in unit processes, coupled with good housekeeping. Many mills are leaky-teaky operations. Management can well decide to pay for tight maintainence and control rather than inflated treatment costs.

The whole aspect of internal control versus external treatment is presently clearly before the industry. Add-on treatment at the end of the sewer has reached limits for many industry waste treatment groups. Production people are involved. New processes are being considered. Research on new pulping methods, condensate stripping, oxygen bleaching, and bleach alterations is underway. National Council is funding a study to determine costs of internal control, step-wise, related to reduced external treatment costs. Management needs this information to make informed decision concerning capital expenditures. Whatever is done will cost money. Obviously older high cost mills will suffer. Capital for either treatment or internal control will be difficult to obtain or justify. However, to presume that any mill has only a choice of external added treatment costs to meet effluent standards is in error.

Given the probability that standardized treatment constructs are not sufficient in themselves to ensure compliance with the waste to product performance standards that are embodied in current regulatory policy, it follows that additional treatment measures and consequent higher costs will be necessary in some cases. In order to gage the approximate magnitude of such costs, an arbitrary schedule of incremental waste treatment measures has been applied to the calculations presented in Table 24. The logic of the schedule does not rest on any technical evaluation, but on the generalization that the greater the indicated deviation of an effluent from the appropriate standard, the more intensive the incremental treatment required for that effluent. Thus:

> Where calculated BOD and/or Solids values are 50% or less in excess of the standard, it is assumed that secondary clarification must be added to the treatment schedule;
>
> Where calculated BOD and/or Solids values are more than 50% and no more than 75% in excess of the standard, it is assumed that stabilization capacity must be augmented 50%;
>
> Where calculated BOD and/or Solids values are greater than 75% and no more than 100% in excess of the standard, it is assumed that both supplemental stabilization capacity and secondary settling must be added to the standardized treatment schedule;
>
> Where calculated BOD and/or Solids values are more than 100% in excess of the standard, it is assumed that the conventional activated sludge process must be substituted for the mechanical clarification plus aerated lagoon treatment sequence assumed in the standard analysis. (Full salvage value is allowed for the standard system.)

The evaluation process indicates that a significant price tag may be placed on implementation of effluent standards. The added investment of more than $90 million exceeds the total requirement remaining to be made under the less precise requirement of "the equivalent of secondary waste treatment." Increase in annual costs of about $12 million also just about doubles the amount of such charges that management might have anticipated under earlier regulatory interpretations. (c.f. Table 1)

Table 25
Illustrative Cost Increments
Associated with BPT Effluent Quality Guidelines

FIRM	LOCATION	TREATMENT INCREMENT			INVESTMENT		ANNUAL COST	
		Secondary Settling	Added Stabilization	Activated Sludge	Total	Per Ton	Total	Per Ton
Alaska Lumber & Pulp	Sitka, AK		X		1,200,000	1,700	180,000	0.70
Boise Cascade	Steilacoom, WA			X	1,400,000	6,400	160,000	2.20
	St. Helens, OR			X	10,700,000	13,400	1,350,000	5.10
	Wallula, WA	X			600,000	800	100,000	0.50
Crown Zellerbach	Port Angeles, WA			X	2,700,000	10,200	300,000	3.40
	Wauna, OR			X	10,800,000	10,800	1,100,000	3.30
	Camas, WA	X			2,500,000	2,200	670,000	1.80
	Lebanon, OR	X			500,000	4,800	80,000	2.50
	West Linn, OR			X	4,800,000	27,000	520,000	8.70
Georgia Pacific	Bellingham, WA		X		1,000,000	1,700	160,000	0.80
Inland Empire	Millwood, WA			X	700,000	10,600	110,000	5.00
International Paper	Gardiner, OR	X	X		1,300,000	2,200	220,000	1.10
Longview Fibre	Longview, WA		X		1,100,000	600	180,000	0.30
Menasha	North Bend, OR	X	X		450,000	3,000	60,000	1.30
Potlatch	Lewiston, ID	X	X		2,100,000	2,100	380,000	1.10
ITT Rayonier	Port Angeles, WA	X			1,200,000	2,500	270,000	1.70
	Hoquiam, WA			X	13,900,000	27,600	1,700,000	10.10
St. Regis Paper	Tacoma, WA			X	6,500,000	7,300	700,000	2.40
Scott Paper	Anacortes, WA			X	1,500,000	10,700	310,000	6.70
	Everett, WA		X		1,000,000	1,200	150,000	0.60
Weyerhaeuser	Everett, WA		X		700,000	1,800	75,000	0.60
	Longview, WA			X	13,600,000	16,100	1,400,000	5.00
	Cosmopolis, WA			X	10,900,000	27,300	1,350,000	10.10
Affected Mills					91,200,000	6,600	11,525,000	2.50
All Region X Mills					91,200,000	4,600	11,525,000	1.70

VI. LIKELIHOOD OF ADDITIONAL MILL CLOSURES

Pulp mills are, on the whole, unlikely to close. Since 1866, forty-eight pulp or pulp and paper plants have come into operation in Region X. As 1972 ends, thirty-three of those forty-eight sites continue to hold operating pulp mills, and at a thirty-fourth site paper production continues even though the pulp mill has closed. Over the period of record, then, the Region has averaged the construction of one new mill every 2.2 years, and only one closure every 7.6 years. Quite clearly, in the long run perspective closure has been perverse behavior; expansion has been the norm.

The reasons are not difficult to lay out. Both population and income are increasing, therefore demand for products, in the aggregate, is increasing. Paper is one of those products for which specific demand has been growing, and much faster than the consuming population--per capita usage of paper has grown faster than per capita income in the U.S. since World War II. Westerr Mills are particularly favored, in that they have direct entree to markets where average income is distinctly above national standards and where population growth is well in excess of the nation's. Abundant forests provide raw materials and intense forest utilization provides sustained flow of those raw materials at prices that are favorable to the industry.

If such fundamental supply/demand relationships explain aggregate expansion, the capital structure of the industry provides at least a partial explanation for the persistence of plants once they have opened. Pulp mills are among the most capital-intensive of all modern factories. Chemical pulping plants built in the U.S. and Canada over the last decade have included $150,000 to $180,000 of investment per ton of capacity installed; ground-wood and semichemical pulping plants have been capitalized at $70,000 to $90,000 per ton of installed capacity. With such enormous investments tied up in plants, there is an obvious reluctance to abandon operational plants. Further, each plant effectively commands access to a certain market and a certain block of raw materials. To abandon it is often to abandon the raw material supply, if not the market. There is compelling reason, then, to improve an existing plant that has become, or threatens to become, unserviceable, in preference to searching for a new production site.

Yet the rate of closure has accelerated over the last two decades. Two pulp plants closed between 1953 and 1962; three plants closed between 1963 and 1972; and four other pulping operations were discontinued, although sites remained active with a modified product process mix. Only three new plants came on stream in the last decade--though the higher than average rate of starts in the previous decade helped to sustain the long term rate of plant starts. In sum, it would appear that the industry is undergoing a process of concentration, at once pruning away marginal mills and expanding more profitable product lines at existing mills, but is opening new mills with greater discretion than in the past.

Factors Related to Closures

The opinion was registered in the initial section of this report that additional pulp mill closures are likely to occur in Region X. That opinion was based on variability in labor productivity, raw materials distribution, and shifts taking place in the product and process mix.

Waste treatment costs are often distinguished as another influence that may influence mill closures. Indeed, if management statements on the occasions of closure can be credited, no other reason for closing a pulp mill can be conceived.

Certainly a review of the mills that have closed in Region X over the past fifteen years lends some credence to the view that waste treatment costs have had an influence on decisions to be shut down. (cf. Table 26) Most of the casualties were sulfite mills, the most difficult and costly to serve with waste treatment. Fully half were within the purview of a Federal Water Pollution Abatement Conference. Three others were under heavy State regulatory pressure to remedy their effluent strength. No closure was free of water pollution control associations.

But to counter the evidence that the cost of water pollution control is a significant variable with respect to ability to sustain the operations of a pulp mill, one needs only to shift his view from the mortalities to the survivors. In general, the higher the degree of waste treatment installed in a geographic sector, the more vigorous the growth of pulp mill output. (cf. Table 27) Costs of waste treatment, then, have proved not only not to be an invariable source of closure, but actually to be no barrier to growth.

The evidence is contradictory, at least on the level of propoganda or of advocate argumentation. We find that (1) plants are forced to close as a result of the costs of water pollution control, and (2) the more that is spent for water pollution control, the more vigorous the growth of the industry.

TABLE 26

MILL CLOSURES, 1957-72

Establishment	Capacity	Product Group	Process	Year of Initial Operation	Raw Materials Area
Boise Cascade, Vancouver	150 T/D	gen'l chemical	ca. sulfite	1921	S.W. Wash.
Crown Zellerbach, West Linn	200	gen'l chemical & groundwood	ca. sulfite	1889	N.W. Ore.
Crown Zellerbach, Port Angeles	90	gen'l chemical & groundwood	ca. sulfite	1919	N.W. Wash.
Fibreboard Paper, Port Angeles	90	gen'l chemical & groundwood	ca. sulfite groundwood	1917	N.W. Wash.
Inland Empire Paper	65	gen'l chemical & groundwood	ca. sulfite	1911	E. of Cascades
Rayonier, Shelton	310	dissolving	ca. sulfite	1926	N.W. Wash.
Simpson-Lee, Everett	173	gen'l chemical	sulfate	1891	N.W. Wash.
Weyerhaeuser, Everett	310	dissolving	ca. sulfite	1956	N.W. Wash.

TABLE 27
REGIONAL GROWTH CHARACTERISTICS, 1963-72
COMPARED TO WASTE TREATMENT
& DISCHARGE CHARACTERISTICS

Location	Capacity	Growth	Effluent Characteristics June 1972			
				Percent Treatment Provided *		
	Tons/day	Percent	BOD_5/T Output	Combustion	Primary	Secondary
Washington Coast	154	21	520	100	100	44
Puget Sound	272	6	470	43	58	0
Alaska	305	29	320	100	0	0
Lower Columbia	1329	31	110	100	100	14
Upper Columbia	572	49	68	100	100	0
Oregon Coast	935	115	45	100	43	0
Willamette	1843	91	12	100	100	100
Region X	5410	36	200	86	79	26

* Based on number of mills providing the service rather than amount of waste water treated or intensity of treatment service provided.

Quite obviously, other factors must provide the explanation for plant closures. To this time, the effect of accommodation to waste treatment requirements would seem to have been random, or to have been dependent on other circumstances.

Again, we may look to the plants that closed for common features that distinguish them. These appear immediately. All were of less than average size; all but one were of greater than average age; seven of the eight were calcium sulfite plants; all produced general chemical pulps or dissolving pulps; and five of the eight were located in northwestern Washington State.

If the focus is shifted from the plants that closed to the relative performance of all Region X pulp mills over the last decade, it is possible to isolate some characteristics that have been associated with growth or decline of a pulp mill. (cf. Table 28) Though patterns are irregular, definite generalizations emerge.

Location: Plants located in northwest Washington were most apt to experience declining fortunes. A location in Alaska or on the lower Columbia River was neutral. Plants located in southwestern Oregon or east of the Cascades were likely to expand.

Size: In general, the larger the plant, the more likely it was to expand; the smaller the plant the more likely to remain static or decline.

Age: In general, the older the plant the more likely that it would remain static or decline and conversely.

Product mix: Mills producing packaging expanded in all cases--and in most cases at a rate greater than average per plant expansion for all regional plants. Dissolving pulp mills and groundwood mills showed little propensity to expand. Mills producing general chemical pulps tended to remain static or decline. (And in other cases of plants operating both groundwood and chemical pulps, the chemical pulp mill was likely to decline.)

Another correlation is apparent, but of little direct use in determining expectations for future performance. Calcium sulfite mills were almost invariably closed or significantly recapitalized, while sulfate mills were likely to expand. With impending closure of the Everett, Washington, sulfite mill, however, only a single calcium sulfite mill will survive in the region. Nor is there enough experience with the various recoverable base sulfite processes to indicate if their performance is apt to be more like that of the calcium sulfite mills from which most of them were converted or the sulfate mills that they now resemble.

TABLE 28
CHARACTERISTICS OF INDUSTRY
DEVELOPMENT, 1963-1972

1. No. of Plants, by Location

Relative Growth	N.W. Wash.	Alaska	N.W. Ore S.W. Wash	S.W. Ore.	E. of Cascades
New Plants	0	0	1	2	0
Expansion ≥ 205 T/D*	0	0	3	4	2
Expansion < 205 T/D	10	2	3	1	0
Capacity unchgd or Declined	2	0	3	0	1
Plant Closures	3	0	1	0	0

2. No. of Plants, by Size (In 1963)

	800 T/D	600-799	400-599	200-399	200
New Plants	1	0	0	2	0
Expansion ≥ 205 T/D	1	2	1	4	1
Expansion < 205 T/D	1	2	4	3	6
Capacity Unchanged or Declined	2	0	3	6	1
Plant Closures	0	0	0	1	3

3. No. of Plants, by Age of Construction

	1954-63	1944-53	1924-43	1914-23	Prior to 1914
New Plants	3	0	0	0	0
Expansion ≥ 205 T/D	5	1	3	0	0
Expansion < 205 T/D	2	2	7	2	3
Capacity Unchanged or Declined	0	0	3	1	3
Plant Closures	0	0	1	2	1

4. No. of Plants, by Product Mix (in 1963)

	Packaging Packaging	Dissolving Pulp	Grdwd.	Gen'l Pulp, Chem.	Gen'l Pulp, Chem & Grdwd
New Plants	2	0	0	0	1
Expansion ≥ 205 T/D	6	0	0	2	1
Expansion < 205 T/D	1	5	1	8	1
Capacity Unchanged, Declined	0	0	0	3	3
Plant Closures	0	1	0	2	1

*Average for all Region X mills over the period.

If, however, one evaluates calcium sulfite mills not in terms of a process set, but as a set of mills that encountered significant capital requirements and added production costs as a consequence of water pollution control regulation, then an additional vulnerability parameter is available to us. For with a single exception, the mills that closed faced an investment in excess of $20,000 a ton of daily capacity to meet the goal of providing the equivalent of secondary waste treatment. Moreover, all of them would have encountered waste treatment costs in excess of $8.50 a ton of output.

Ways In Which Waste Treatment Costs May Influence Closures

Recognizing, then, that waste treatment costs, like any other operational variable, can play some part in decisions to continue to operate, to expand, or to close a particular mill, it is desirable to examine those factors associated with waste treatment that have a direct bearing on such decisions.

The most obvious conclusion that one can draw is that waste treatment costs are not in themselves sufficient to cause mills to close. The intra-regional evidence has been provided in this report. On a national scale, the Council on Economic Priorities has presented similar evidence in Paper Profits: Pollution Audit 1972 (New York: July 1972). The Council has found that 106 of 123 pulp mills operated by 22 major paper companies either have installed or have planned to install primary waste treatment, and that 85 of them have or have planned to install secondary waste treatment (cf. Table 29). It is clear that the industry has been able to adapt to regulation. Indeed, it would have been surprising to discover anything else. Once regulation had become more or less effectively standardized for pulp mill effluents throughout the nation, treatment costs became a general component of values added for the industry. Mills providing waste treatment no longer experience significant competitive disadvantage vis a vis other pulp and paper mills as a consequence of treating wastes.

But if waste treatment as a class of cost-imposing phenomenon is not sufficient to cause productive facilities to be taken out of operation, relative waste treatment costs must be considered to be a significant factor in capital elimination decisions.

This is considered to be probable for two reasons: (1) A waste treatment charge greater than that of a competitor will reduce relative profit on each unit of output by precisely the amount of the difference, all other things being equal; (2) but all other things are not equal, which is, in fact, the prime reason that waste treatment costs are significant in mill closures.

TABLE 29
STATUS OF MAJOR FIRMS' WASTE TREATMENT, 1972, AS REPORTED BY COUNCIL ON ECONOMIC PRIORITIES

Firm	Mills	Waste Treatment Provided: Primary	Secondary	Closures 1970-72
American Can	4	2	2	
Boise Cascade	6	6	4	
Champion International	3	3	3	
Consolidated Papers	5	2		1
Continental Can	4	3	3	
Crown Zellerbach	9	8	3	
Diamond International	4	2	2	
Fibreboard	1	1		
Georgia Pacific	9	5	2	
Great Northern Nekoosa	6	3	2	
Hammerhill	4	2	2	1
Hoerner Waldorf	3	2	2	
International Paper	16	15	13	
Kimberly Clark	2	2	2	
Marcor	3	3	1	
Owens-Illinois	4	4	4	
Potlatch Forests	2	2		
St. Regis Paper	9	6	3	2
Scott Paper	10	7	3	2
Union Camp	3	3	2	
Westvaco	6	4	1	2
Weyerhaeuser	10	9	7	
Total	123	94	61	8
Scheduled for 1973 or later		12	24	

TABLE 30

Correspondence Between Average Waste Treatment Costs
And Other Expansion/Decline Characteristics

Mills ranked from most vulnerable to closure, 1953 - 1972, to least vulnerable to closure.		Average waste treatment cost per ton of output for mills active in 1972 (best practicable treatment)	
1. Location:	Northwest Washington	$ 8.40	
	N.W. Oregon/S.W. Wash.	7.50	
	Alaska	7.30	
	East of Cascades	3.20	
	Southwest Oregon	2.10	
2. Age:	Constructed prior to 1924	9.50	
	1924-43	7.50	
	1944-53	5.70	
	1954-63	3.60	
	Constructed since 1963	5.40	
3. Size:	Less than 200 T/D capacity	14.20	
	200-399 T/D	9.60	
	400-599 T/D	6.90	
	600/800 T/D	5.20	
	Greater than 800 T/D	5.40	
4. Product Mix:	General Chemical Pulp	8.00	
	Dissolving pulp	10.60	
	Groundwood pulp	10.90	
	Gen'l chem/grwd pulp	5.70	
	Packaging & board	2.20	

Waste treatment is simply an incremental processing step that adds to and recapitulates the sum of the relative efficiency of all prior operating factors. Thus the mills with higher waste treatment costs tend to be the same mills that have higher labor costs, higher material costs, and even less advantageous raw material situations. There is a startling correlation between the average waste treatment costs of plant grouping and the relative growth or decline of the same groups of plants in Region X over the last decade. (cf. Table 30)

These concepts are unexceptionable, and trace to the second mechanism by which waste treatment may affect the survival of factories. Waste treatment is, after all, no more than a minor alteration of much larger operational environment. The principal feature of that environment is relative capitalization--the time-conditioned amount of structure, machinery, and energy available per unit of labor or raw material input. A high relative unit waste treatment cost is invariably associated with relatively wasteful use of water as a raw material and a high rate of loss of wood inputs. It is, then, a useful indicator of an amount of capital and energy insufficient to convert those raw materials into product as efficiently as do other mills.

Other characteristics of a mill--age, size, product and process mix--may also be seen as inexact surrogates for the basic datum, relative capitalization. Greater age suggests less current capital per unit of capacity--a simple function of depreciation. But a mill like the Scott Paper Company mill at Everett, which is undergoing its third sweeping recapitalization since its acquisition in the nineteen-forties, cannot be considered an old mill in any comparative sense. Conversely, the Scott Paper Mill at Anacortes has received no significant capital expenditures for more than a decade. It is an old mill by any practical standard--and its waste treatment cost per unit of product demonstrates spectacularly what that must mean to its profitability.

The waste treatment cost model indicates that Region X mills must invest roughly $200 million in waste treatment facilities over the next five years in order to be in compliance with effluent standards; and another $25 - 30 million will be required for capital maintenance for waste treatment facilities. That capital is a substantial segment--roughly one-fourth--of the $170 million a year required to maintain the existing stock of productive capital installed in the Region by the woodpulp industry. (Assumes current replacement value of capital of $175,000 per ton of capacity and a five percent capital recovery rate.) Quite obviously, the reduction in discretionary capital utilization means (and particularly

in view of the high cost of capital) that the industry must exercise austerity in alloting its investment funds.

Since waste treatment requirements include a rigorous schedule and progressivity, management is unlikely to install the facilities in mills that are due to be phased out. And without the requisite facilities, phase-out schedules become extraordinarily transparent. The lease on life of mills that are too small, too old, or otherwise too unprofitable to be renovated runs only through June 30, 1977, when best practicable treatment becomes an operational requirement.

In practical terms, then, waste treatment costs will influence mill closures in two ways:

1. By reinforcing existing marginal advantage, waste treatment costs make profitable mills even more profitable relative to their competition. Thus they contribute to existing trends that favor concentration, specialization, less and larger productive units.

2. By placing an effective time limit on the productivity of capital invested in mills slated for closure, Federal water pollution control law deters interim investments that might prolong the operating life of such mills. Capital will be diverted, then, to favorable locations; and the closure/concentration process is again accelerated.

Relative Vulnerability to Closure

Given the set of parameters that correlate with past mill closures--size, age, location, and product mix--it is possible to array the mills that compose the Regional woodpulp industry in a manner that displays the distribution of those relative vulnerability to closure variables. Any such ranking could be considered to constitute a very gross indicator of probability of closure.

Consideration of adjustment to waste treatment regulations probably sharpens the probabilities very significantly. It allows a plant-by-plant comparison, within product lines, of the relative operational efficiency of competing mills with respect to at least one cost factor. Even more valuable, perhaps, is the indication that such an analysis provides of management's ability and willingness to invest at a particular site. (cf. Table 31)

The indicator value of relative costs and relative capitalization of waste treatment is, nevertheless, somewhat blurred by other factors. Lack of investment in waste treatment is a possible

measure of reluctance to invest at a particular site. It is also a possible measure of regulatory slackness or of a company policy that dictates resistance to imposed investment, up to the point of ultimate confrontation. Similarly, a high waste treatment cost may measure nothing more than the fact that investment has been deferred, since installation of treatment may be accompanied by modifications of water use practices that substantially reduce treatment costs.

Nonetheless, a plant-by-plant review of the regional industry in terms of the distribution of six parameters that either have in the past or may be expected to contribute to closure must suggest in a broad manner whether any particular plant is more likely to be closed within the next five years than any other particular plant.

Such an array is presented in Table 32. Plants were graded from one (least likely to close) to five (most likely to close) with respect to the four general categories developed in Table 28. They were further graded according to relative cost of waste treatment and relative availability of waste treatment capital. 'Vulnerability ranking was as follows:

TABLE 31
Waste Treatment Costs
Ranked by Product Groups

FIRM	Location	Daily Capacity	Year Constructed	Cost Per Ton	Treatment Capital Installed
Western Kraft	Albany, OR	770 tons	1955	$1.10	100%
Georgia Pacific	Toledo, OR	1000	1958	1.40	0
Weyerhaeuser	Springfield, OR	1155	1949	1.50	100
Boise Cascade	Wallula, WA	666	1959	1.80	50
Longview Fibre	Longview, WA	1850	1926	2.50	54
International Paper	Gardiner, OR	600	1964	3.50	44
American Can	Halsey, OR	330	1970	4.30	100
Menasha	N. Bend, OR	150	N.A.	5.30	39
1. Packaging & Board Group		815	1954	2.20	59
Boise Cascade	Steilacoom, WA	220	1919	6.10	37
Crown Zellerbach	Port Angeles, WA	226	1919	8.50	31
Inland Empire	Millwood, WA	66	1911	12.30	43
Crown Zellerbach	West Linn, OR	180	1889	19.90	42
2. Groundwood Group		183	1910	10.90	38
Alaska Lumber & Pulp	Sitka, AK	725	1956	6.40	0
Ketchikan Pulp	Ketchikan, AK	630	1958	8.30	0
Rayonier	Port Angeles, WA	486	1930	8.60	0
Weyerhaeuser	Cosmopolis, WA	400	1951	16.40	27
Rayonier	Hoquiam, WA	504	1928	16.70	16
3. Dissolving Pulp Group		549	1945	10.60	12
Publishers Paper	Newberg, OR	500	1927	3.50	100
	Oregon City, OR	594	1908	5.10	100
Crown Zellerbach	Wauna, OR	1003	1967	7.00	22
4. General Pulps, Chemical & Groundwood		699	1934	5.70	53
Potlatch Forests	Lewiston, ID	1000	1956	3.60	44
Crown Zellerbach	Port Townsend, WA	405	1927	4.10	0
St. Regis Paper	Tacoma, WA	887	1926	5.30	25
Scott Paper	Everett, WA	836	1928	6.80	32
Weyerhaeuser	Everett, WA	410	1953	7.00	0
Georgia Pacific	Bellingham, WA	572	1926	7.40	0
Boise Cascade	St. Helens, OR	800	1926	8.30	29
	Salem, OR	250	1920	10.00	100
Crown Zellerbach	Camas, WA	1145	1883	10.30	79
	Lebanon, OR	99	1889	13.60	85
Weyerhaeuser	Longview, WA	846	1931	14.00	19
Scott Paper	Anacortes, WA	140	1924	17.70	26
5. General Chemical Pulp Group		616	1924	8.00	39
6. All Mills		609 Tons	1934	$6.50	36%

CLOSURE TENDENCIES

RANK	1	2	3	4	5
LOCATION	Southwest Oregon	East of Cascades	Alaska	Lower Columbia	Northwest Washington
SIZE	≥ 800 T/D	600-799 T/D	400-599 T/D	200-399	< 200 T/D
AGE	1961 or later	1951-60	1931-50	1921-30	1920 or before
PRODUCT MIX	Packaging	General Chemical & Groundwood	Groundwood	Dissolving	General Chemical
TREATMENT INVESTMENT	100% installed	≥61%	31-60%	≤30%	00%

(Based on Equivalent of Secondary Waste Treatment)

TREATMENT COST	Lowest in Group	≤75% Product Group Mean	76-125% Product Group Mean	≥126% Product Group Mean	Highest in Group

(Group Means are: Dissolving Pulp $10.60/T
General Pulp and Groundwood $ 7.40/T
Packaging $ 2.20/T)

As one might expect, given the logic of the rankings, the most vulnerable third of all mills, when parameters consistent with past closures is considered, is composed predominantly of plants located on Puget Sound. Their location, their average age, their average size consigns the Puget Sound Mills to that position. Consideration of the specific indicators provided by accommodation to waste treatment considerably alters the order of the components, however. (cf. Table 32)

One may expect with a high degree of confidence that closures, if any, will come from mills in the highest third of the adjusted ranking. Two plants--the first and third in the adjusted ranking--have, in fact, already announced closures. Two other plants seem very likely to close. At least two more must be considered to be vulnerable to the interaction of effluent limits with other trends in force in the industry. The index numbers certainly are not precise enough to provide a defensible grip on closure probabilities for specific plants, though consideration of qualitative factors may sharpen our insights.

1. Simpson-Lee, Everett, Washington, closed in the fall of 1972.

2. Scott Paper Company, Anacortes, Washington, would seem to be an almost certain candidate for closure. There have been no avoidable capital expenditures at the site for over a decade. It is the second smallest chemical pulp mill in the region. Its specialized raw material requirements are in uncertain supply. It is not an integrated mill--little more than an operational appendage of Scott Paper's Everett Mill, in fact, and with the inconvenience and cost of an added transportation step between pulp production and paper machine.

One must speculate that the decision to close this mill has probably already been made. The company is currently undertaking a $60 million construction program at Everett. Ostensibly, the investments are for environmental purposes. But it is inconceivable that so great an amount could possibly be invested in air and water pollution control, even with the most incompetent engineering available. (Sixty million dollars is, after all, 20 percent more than Weyerhaeuser spent to build a totally new 500 T/D mill in North Carolina only last year.) In all probability, the Everett Mill is undergoing a complete refurbishing from which it will emerge with a significant (150 T/D or more) capacity increment that will allow the closure of the Anacortes mill with no loss of capacity and no surrender of raw material sources by the firm.

Table 12
Plants Ranked From Highest
To Lowest In Indicated
Exposure to Closure

RANK	PLANT	General Parameters: Age	Size	Location	PDT MIX	Index	Investment: Relative Vulnerability	Index	Cost: Relative Vulnerability	Index	Adjusted Rank
1	Simpson Lee, Everett	5	5	5	5	1.000	4	1.000	4	.867	1
2	Scott Paper, Anacortes	4	5	5	5	.950	3	.880	4	.867	2
3-6	Boise Cascade, St. Helens	5	4	4	3	.850	2	.760	3	.733	6-10
	Crown Zellerbach, Port Angeles	5	4	5	3	.850	2	.760	4	.767	3-7
	Crown Zellerbach West Linn	5	5	4	3	.850	1	.720	5	.767	3-7
	Boise Cascade, Salem	5	4	4	3	.850	1	.720	4	.733	6-10
7-11	Weyerhaeuser, Everett	5	4	5	4	.800	4	.800	4	.800	3-4
	Georgia Pacific, Bellingham	5	4	5	5	.850	3	.840	3	.800	3-4
	Crown Zellerbach, Port Townsend	5	4	5	3	.800	3*	.760	4	.700	11-16
	Crown Zellerbach, Lebanon	5	5	5	3	.800	1	.680	4	.700	11-16
	Publishers Paper, Oregon City	5	4	4	3	.800	1	.680	4	.633	17-19
12-17	Kaysner, Longview	4	4	5	4	.750	4	.720	5	.767	3-7
	St. Regis, Tacoma	4	4	5	4	.750	3	.720	4	.700	11-16
	Inland Empire, Millwood	4	5	4	4	.750	3	.680	4	.700	11-16
	Scott Paper, Everett	4	4	4	5	.750	2*	.640	4	.600	20-23
	Crown Zellerbach, Camas	5	4	4	3	.750	2	.680	4	.700	11-16
	Publishers Paper, Newberg	4	4	4	4	.750	1	.640	4	.600	20-23
18-20	Weyerhaeuser, Everett	4	4	4	3	.700	5	.760	4	.733	8-10
	Kaysner, Port Angeles	4	4	4	4	.700	2*	.640	4	.600	20-23
	Boise Cascade, St. Helens	4	4	4	3	.700	1	.600	4	.600	20-23
21-22	Weyerhaeuser, Longview	4	4	4	3	.650	4	.680	4	.700	11-16
	Weyerhaeuser, Cosmopolis	4	4	4	4	.650	3	.560	4	.600	20-23
23-24	Ketchikan Pulp, Ketchikan	4	4	4	4	.600	5	.680	4	.633	17-19
	Alaska Lumber & Pulp Sitka	4	4	4	4	.600	5	.680	4	.600	20-23
25-26	Menasha, North Bend	4	5	4	4	.550	3	.560	4	.633	17-19
	Crown Zellerbach, Hauna	4	4	4	3	.550	2	.520	4	.533	26
27	Longview Fibre, Longview	4	4	4	4	.500	2	.480	4	.500	27
28	Boise Cascade, Walluia	4	4	4	4	.400	2	.440	4	.400	28-31
29-30	American Can, Halsey	4	4	4	4	.350	2	.320	4	.400	28-31
	Western Kraft, Albany	4	4	4	4	.350	2	.320	4	.300	32-34
31-33	International Paper, Gardiner	4	4	4	4	.300	2	.320	4	.400	28-31
	Potlatch Fibre, Lewiston	4	4	4	4	.300	2	.320	4	.300	32-34
	Weyerhaeuser, Springfield	4	4	4	4	.300	2	.280	4	.300	32-34
34	Georgia Pacific, Toledo	4	4	4	4	.250	5	.400	4	.400	28-31

(Enclosed Plants Announced Shut Down in 1972)

* Gives effect to current construction program

3. Weyerhaeuser Company, Everett, Washington, sulfite mill is scheduled for closure at such time as it can no longer secure a waste discharge permit (apparently March 1974). The mill would seem to be a casualty of raw material constraints in Northwest Washington, the corporation's decision to de-emphasize Pacific Northwest operations relative to those in British Columbia and the Southeast, and Weyerhaeuser's traditional financial conservatism. A cash flow squeeze brought on by continuing expansion in other areas, a probable fundamental recapitalization of the Longview, Washington, complex, and the pressure of environmenatal regulation at a number of locations probably led to the decision to allow this unit--which would have been unlikely to be able to expand to the optimum size for operation of modern mills by reason of raw material scarcity--to lapse. It should be noted that the eventual release of the mill's raw materials requirements improves the relative probability of survival of other mills on Puget Sound and Grays Harbor, and in particular of the Weyerhaeuser sulfate mill at Everett and the other dissolving pulp mill at Cosmopolis.

4. Georgia Pacific Company, Bellingham, Washington, is vulnerable to closure in terms of the indicator factors used in determining the index of likelihood of closure, but those factors must be viewed in terms of management philosophy.

Location and age are apparently unfavorable factors, but the effective age of the plant, giving effect to a series of capital improvements over the years, is well below its chronological age. Location, too, must be interpreted in terms of the inter-relationship among producers. This report has concluded that Northwest Washington is an unfavorable location largely because of strictures on expansion imposed by the high level of raw material utilization. As weaker units close, the unfavorable situation of the survivors in Northwest Washington will be altered. So the closure of the Simpson-Lee and Weyerhaeuser mills improves the relative viability of this mill.

Finally, the waste treatment factors that enter into the Bellingham mill's high apparent vulnerability ranking are very deceptive. On the one hand, Georgia Pacific's management philosophy produces an impression of unwillingness to risk capital at the mill that is almost certainly false, and on the other hand, a novel technological approach to waste controls understates the effects, and may overstate the costs, of waste controls already achieved.

Georgia Pacific has the reputation of being the swinger of the forest products industry. It spreads its capital thin and employs maximum leverage. It is recognized for its efforts in the direction of short run output volume, profit maximization, and product development, not for its prudence or attention to long run side effects of its activities. If that is an adequate description of the corporate psychology, it is only to be expected that Georgia Pacific would defer waste treatment investments--or any other diversion of capital from profit making purposes--as long as it possibly might. Viewed in that light, the lack of environmental protection capital at Bellingham (as at Toledo, Oregon) cannot be taken as an indicator of vulnerability so much as an expression of corporate policy.

Similarly, the dimensions of the treatment deficiency and of treatment costs associated with the Bellingham Mill are probably overstated. The mill has attempted to recover pulping liquor wastes as salable products rather than in the form of recyclable raw materials. The apparent deviation from the standardized treatment procedure may suggest a degree of deficiency and exposure to cost that is well beyond actual limits of performance. Whether Georgia Pacific can eventually meet Federally imposed effluent guidelines by following the heterodox technological route it has adopted is an open question. Certainly there is no reason to assume an adverse result.* In any case, the mill is not considered likely to close.

5,6,8,11. Crown Zellerbach at Port Angeles, Washington; West Linn, Oregon; Boise Cascade at Steilacoom, Washington; and Inland Empire Paper Company at Millwood, Washington, Region X's four groundwood mills, must all be considered to be vulnerable to closure. In their cases, the association of possible closure with water pollution control regulation is far more direct than in others. With the exception of the Boise Cascade unit, the groundwood mills appear to face investments equal to one fourth to one fifth of their current replacement value if they are to

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* With respect to this, Ralph Scott has noted:

> The utilization of SSL by Georgia Pacific at Bellingham is, conservation-wise, a much preferable mode of operation than low value heat recovery With about one half of input wood substance in solution in sulfate or sulfite cooking liquor, a mill with a strong by-product research and development effort should enjoy a preferred position. This may also be true of Boise Cascade at Salem after they solve current problems. It may also well explain the continued operation of Crown Zellerbach at Lebanon. The main hurdle mills face is breaking into the by-product field from the marketing standpoint. Many chemicals and products are possible. Development of significant markets in competition with petrochemicals or other organic chemical sources is a principal hangup.

meet "best practicable treatment" levels of performance. The mills are old, they are small, they survive in large part because they supply a near proprietary local market with a low grade product (mostly newsprint, some specialty packaging) in whose production they are competitive because (1) products incorporate a low capital cost component because of near total depreciation of facilities, and (2) negligible transportation charges. They appear, then, to be caught in a squeeze between an operating regimen based on low current capitalization, location and size and age characteristics that do not favor expansion, and a regulatory demand for significant--at least in terms of groundwood capitalization standards--new investments.

The difficulty of their conditions is the more extreme, in that it is uncertain that the stringent effluent limitations set for groundwood pulp can be met with even the most expensive treatment process combinations. No groundwood mill in the Northwest even approaches the treatment effectiveness levels set under the best practicable treatment guidelines. Those groundwood mills that do appear to meet the standards incorporate groundwood wastes with those of chemical pulping, achieving both a masking effect and economies of scale not available to these four small mills.

The past is, perhaps, a good guide to the future. Three of the same four plants have already met the imposition of waste treatment requirements by closing a pulp mill. Inland Empire Paper Company and the two Crown Zellerbach mills found it less expensive to buy chemical pulp inputs than to continue to produce calcium sulfite pulps with the added cost of waste treatment. It is entirely logical that the same decision will be followed for the groundwood pulping operations. The addition of waste treatment could raise the cost of groundwood produced on site above the cost of purchased chemical pulp, in which case the paper machines might continue to operate after the pulp mills go down.

The best opportunity for these mills to stay in operation would appear to be found through resort to a technical loophole. Given primary treatment--which all four provide--the wastes of the three Washington mills could be discharged to available municipal sewage handling systems, where the effluent requirements might better be met. The relative cost of such a situation--and the risks to municipalities of installing the significant added capacity to accommodate a single waste source--remain to be thoroughly investigated.

At any rate, the probability of closure is considered to be high in every case. Inland Empire Paper Company's pulp mill is thought to be almost certain to close. The groundwood mill at West Linn (not the paper mill) must be considered to rank next in line in relative vulnerability, because of the ready availability of pulp from other Crown Zellerbach mills in the immediate area. Boise Cascade's Steilacoom plant is probably the least vulnerable of the four groundwood mills, on the basis of recent capital improvements, relatively low waste treatment costs, and lack of immediate owned sources of pulp. But even it cannot be considered fully safe.

7. ITT-Rayonier, Hoquiam, Washington, would appear to be vulnerable on the basis of adjustments in dissolving pulp technology and an extraordinarily high waste treatment cost. But while the mill is probably not so well situated as the same firm's Port Angeles mill, there are indications that the suggested waste treatment costs are deceptive. On the basis of reported values, one must conclude that accommodations to waste treatment requirements that have been made to date have been perfunctory; and that actual capitalization and costs incurred are well below those calculated. If so, adjustment to the more stringent treatment requirements that are currently imposed would prove to require less total capital and cost than is indicated by the treatment cost models. The competitive and raw material situation of the mill is in the process of being improved as other mills are being weeded out. It would not seem likely that this plant will close.

9. Boise Cascade, Salem, Oregon, would appear, on the basis of capital improvements made by Boise Cascade since its acquisition of the plant, to hold a firm position in the corporate operating structure. Environmental protection problems, and consequent added production costs, appear to be a continuing source of friction, but management appears to be moving consistently in the direction of accommodation to air and water pollution control standards, accepting costs that would be avoided if early closure were contemplated. Closure seems most unlikely.

10. Weyerhaeuser Company's Everett, Washington, sulfate mill would also seem relatively immune to closure. If anything, the closure of the sulfite mill in the same town strengthens this plant's situation, in that implies Weyerhaeuser's obvious production reorientation in the Pacific Northwest will include emphasis on this mill as the focus of its Puget Sound operations.

12. Crown Zellerbach, Lebanon, Oregon, is a continuing anomaly. It has operated for eight decades without significant expansion. It is the smallest calcium sulfite mill in the nation to be converted to a recoverable base pulping process. It has adjusted to environmental controls that have resulted in the closure of mills that were much better situated--at least on paper.

The plant seems to have survived as a specialty mill, producing production runs too small and too specialized to be handled conveniently by major plants. It also serves as a sort of operational laboratory, in which product and process modifications--including pollution control methods--are tested on a prototypical scale. Its pollution control adjustments, then, have in some measure been underwritten by the corporation for the utility they might provide in the broader context of the firm. They seem, too to have been made on the cheap, if the Council on Economic Priorities estimate of a total investment of $600,000 for air and water pollution control is reliable.

In spite of the complete adjustment to water pollution control requirements and the favorable location from a raw materials standpoint, the mill must be presumed to be highly vulnerable to closure on the basis of size, age, and product mix. The same judgment might, however, have been made at any time in the last twenty years. The normal analytical conclusion throughout that period would have been that Crown Zellerbach must either expand or close the Lebanon mill. And yet the firm has shown no disposition to do either to this time.

Table 33
'Vulnerable' Mills Ranked According to
Indicated Exposure to Closure

1. Closures announced:

   Simpson-Lee, Everett, Washington, 173 T/D sulfate mill, paper mill, and paper converting mill

   Weyerhaeuser, Everett, Washington, 310 T/D sulfite pulp mill

2. Closure probable:

   Scott Paper Company, Anacortes, Washington, 140 T/D sulfite pulp mill

   Inland Empire Paper Company, Millwood, Washington, 66 T/D groundwood mill.

3. Closure a definite possibility:

   Crown Zellerbach Company, West Linn, Oregon, 180 T/D groundwood pulp mill

   Crown Zellerbach Company, Port Angeles, Washington, 266 T/D groundwood pulp mill

4. Closure possible, less likely than above:

   Boise Cascade Company, Steilacoom, Washington, 220 T/D groundwood pulp mill

   Crown Zellerbach Company, Lebanon, Oregon, 99 T/D sulfite pulp and paper mill

5. Closure unlikely in spite of unfavorable factors:

   Georgia Pacific Company, Bellingham, Washington, 572 T/D sulfite pulp mill

   ITT-Rayonier, Hoquiam, Washington, 504 T/D sulfite pulp mill

   Boise Cascade Company, Salem, Oregon, 250 T/D sulfite pulp mill

   Weyerhaeuser Company, Everett, Washington, 410 T/D sulfate pulp mill